

CROP PRODUCTION AND IRRIGATION MANAGEMENT UNDER SALINE CONDITIONS

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Tunis, 12 December 2022

Regional gathering
Tunis, 12 – 16 December 2022





Contents

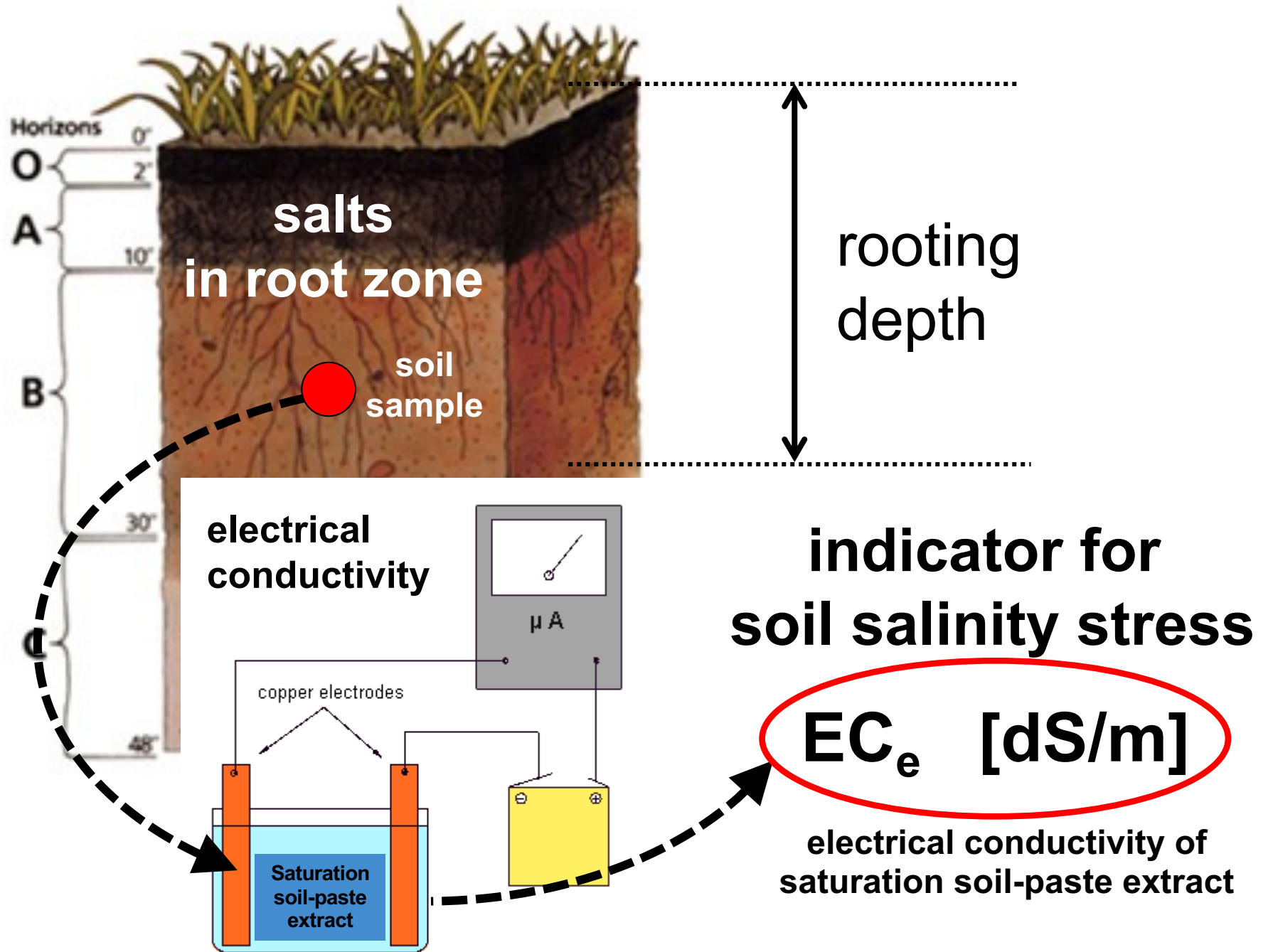
Theoretical aspects

- ➔ **Simulation of soil salinity in AquaCrop**
- **Evaluation of the salt balance**

Applications

- **Crop production under saline conditions**
- **Leaching by winter rains**

Indicator for salinity stress





Salt accumulation and removal

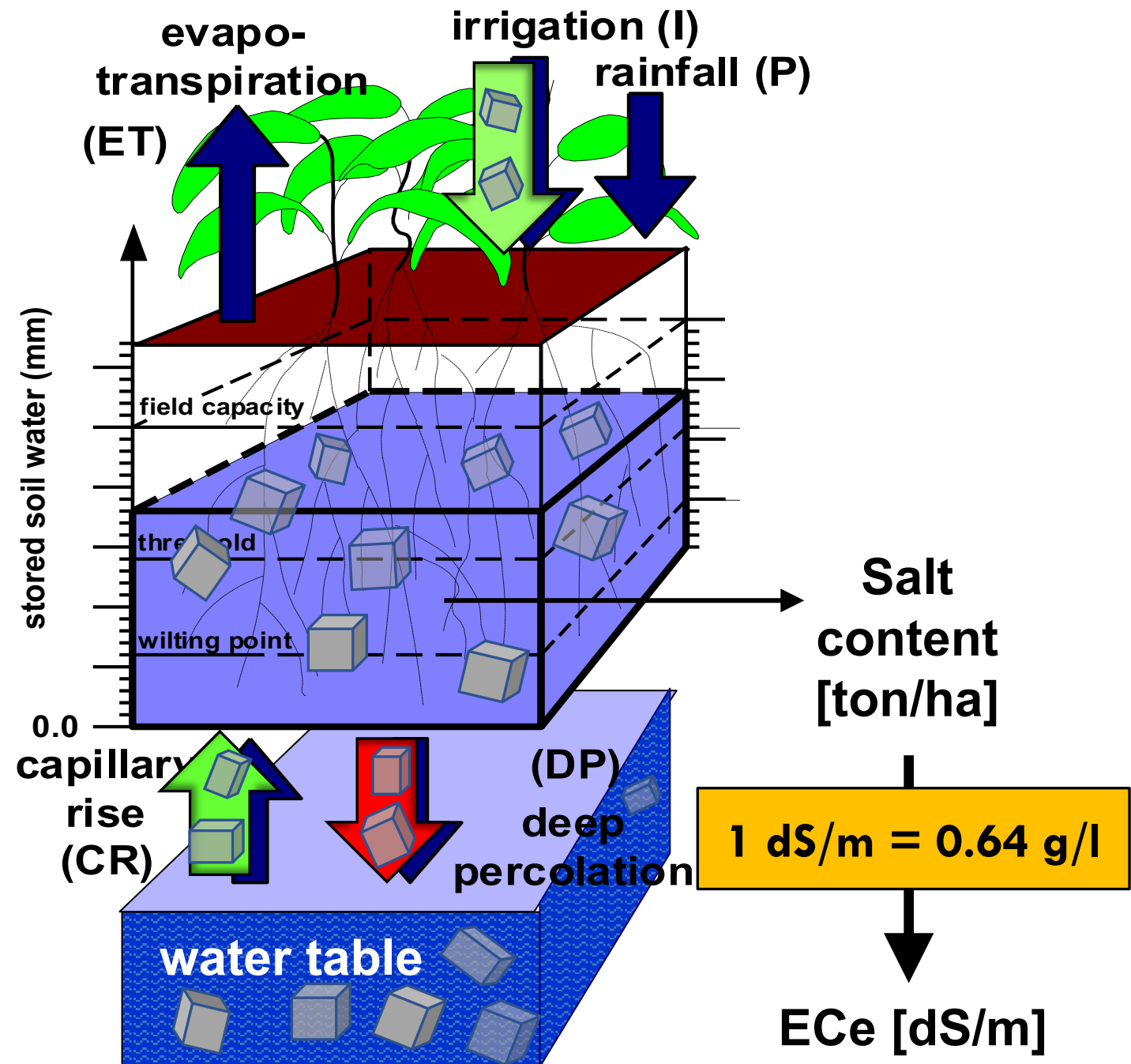
Salt balance

input

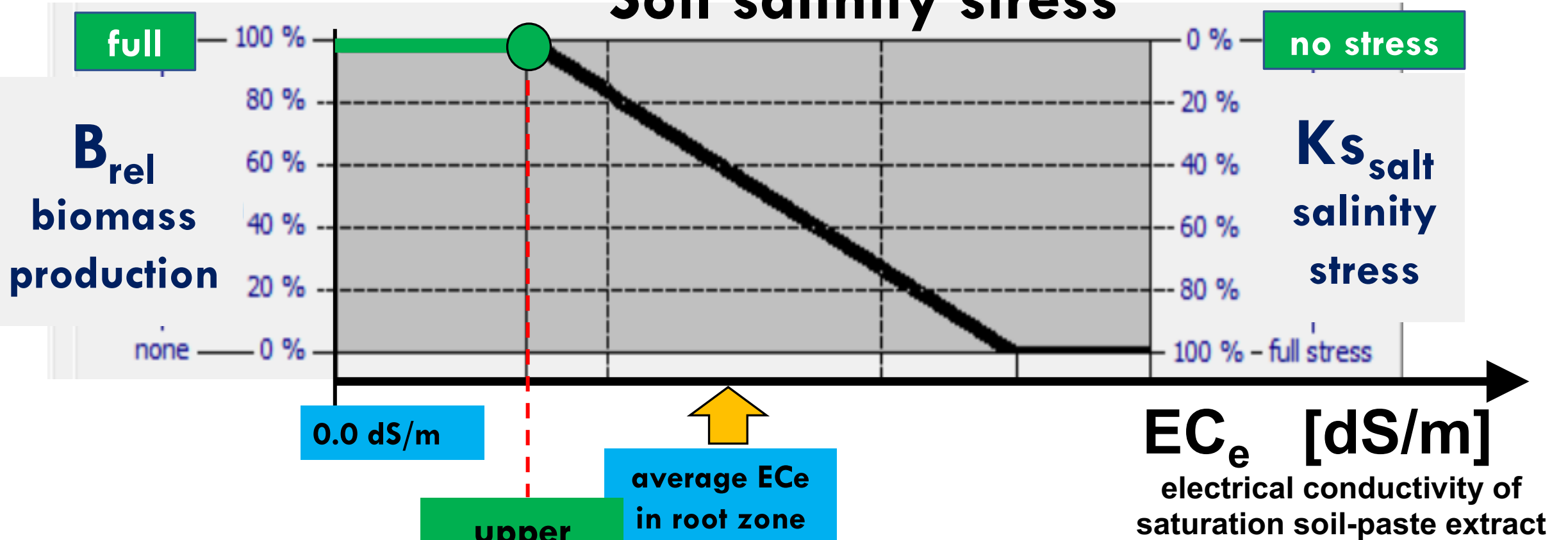
- Irrigation water
- Capillary rise from saline groundwater table

removal

- Leaching (deep percolation)

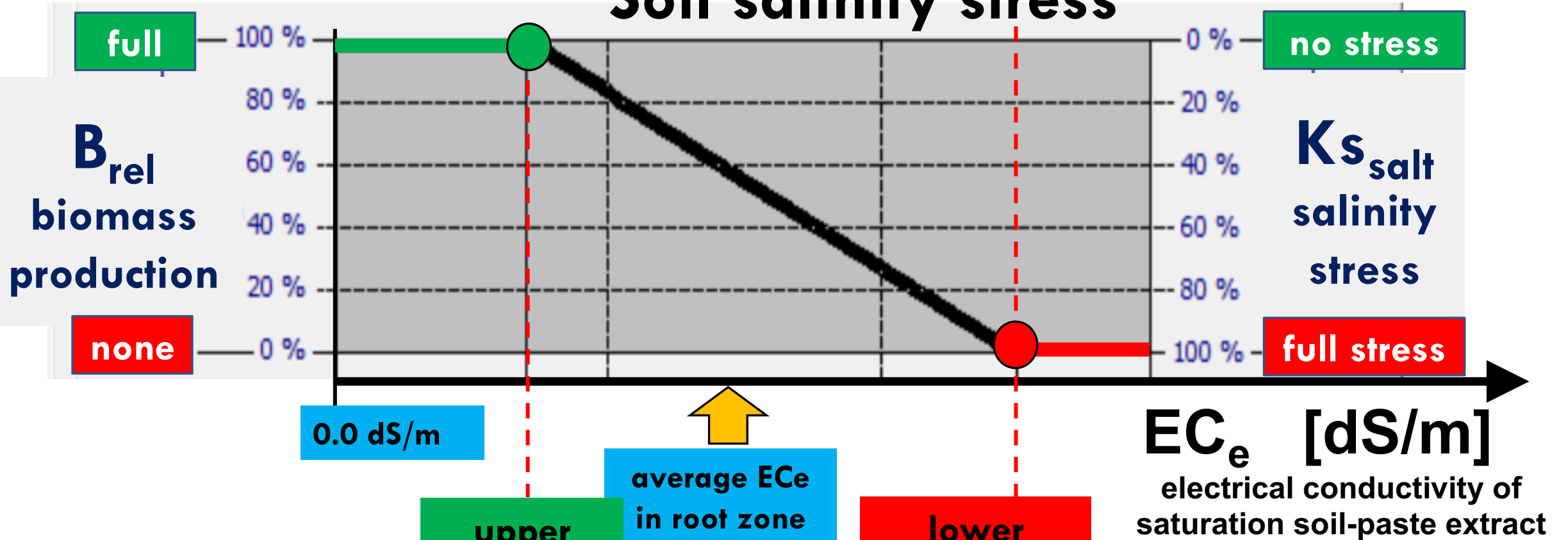


Soil salinity stress



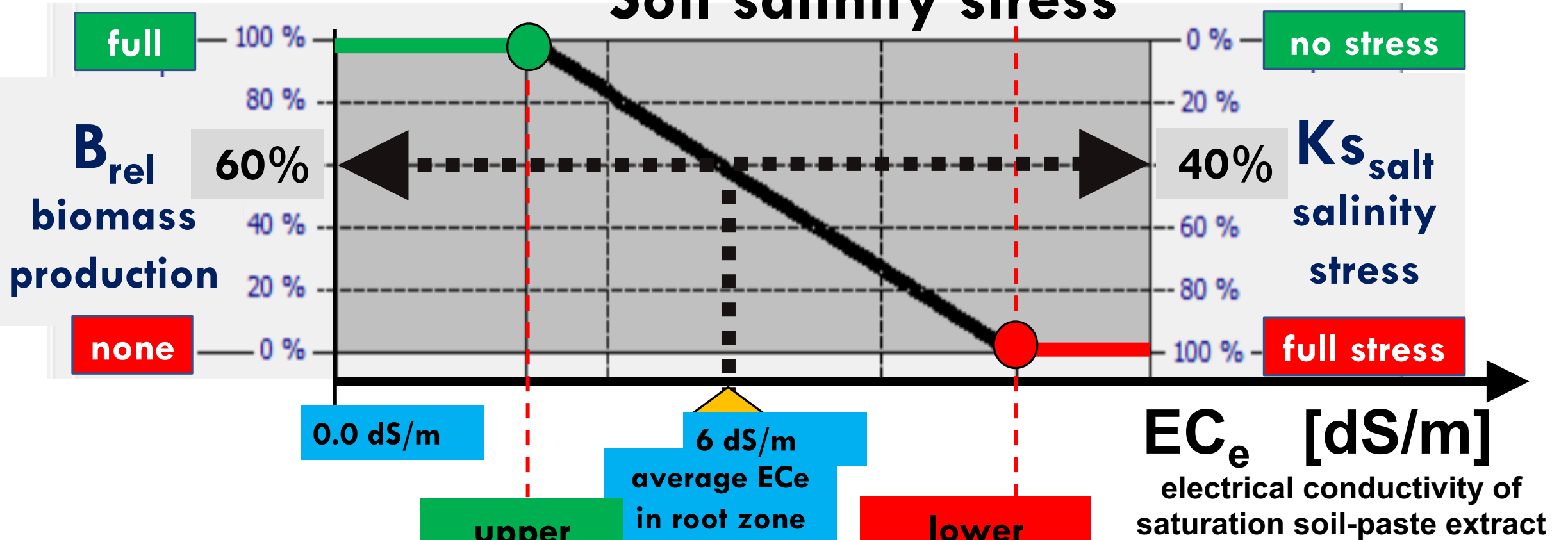
Crop	upper threshold	average EC_e in root zone	EC_e [dS/m]	electrical conductivity of saturation soil-paste extract
Rice	3			Sensitive

Soil salinity stress



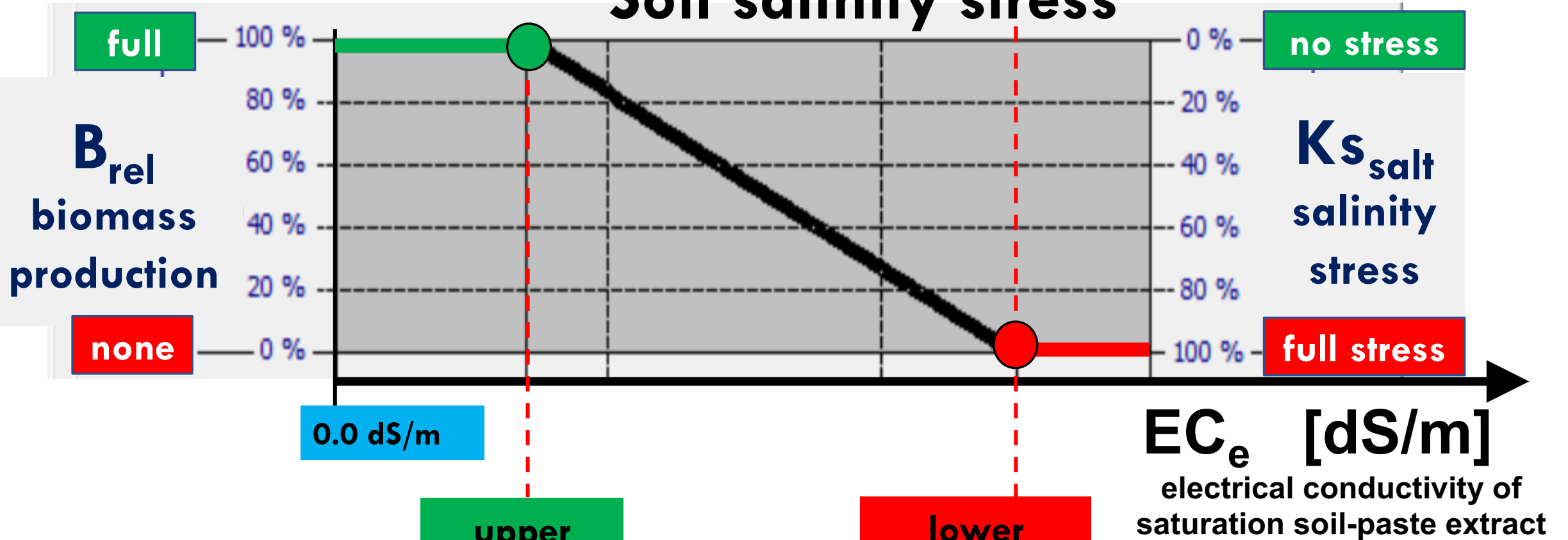
Crop	upper threshold	lower threshold	
Rice	3	11	Sensitive

Soil salinity stress



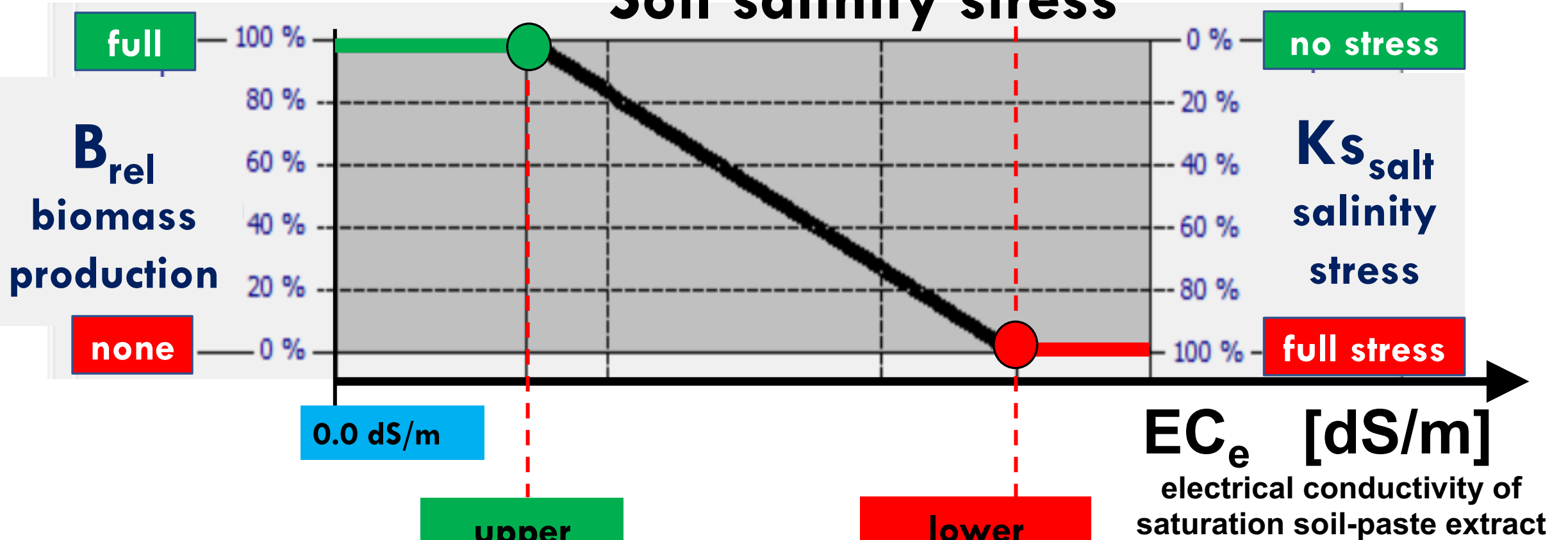
Crop	upper threshold	lower threshold	
Rice	3	11	Sensitive

Soil salinity stress



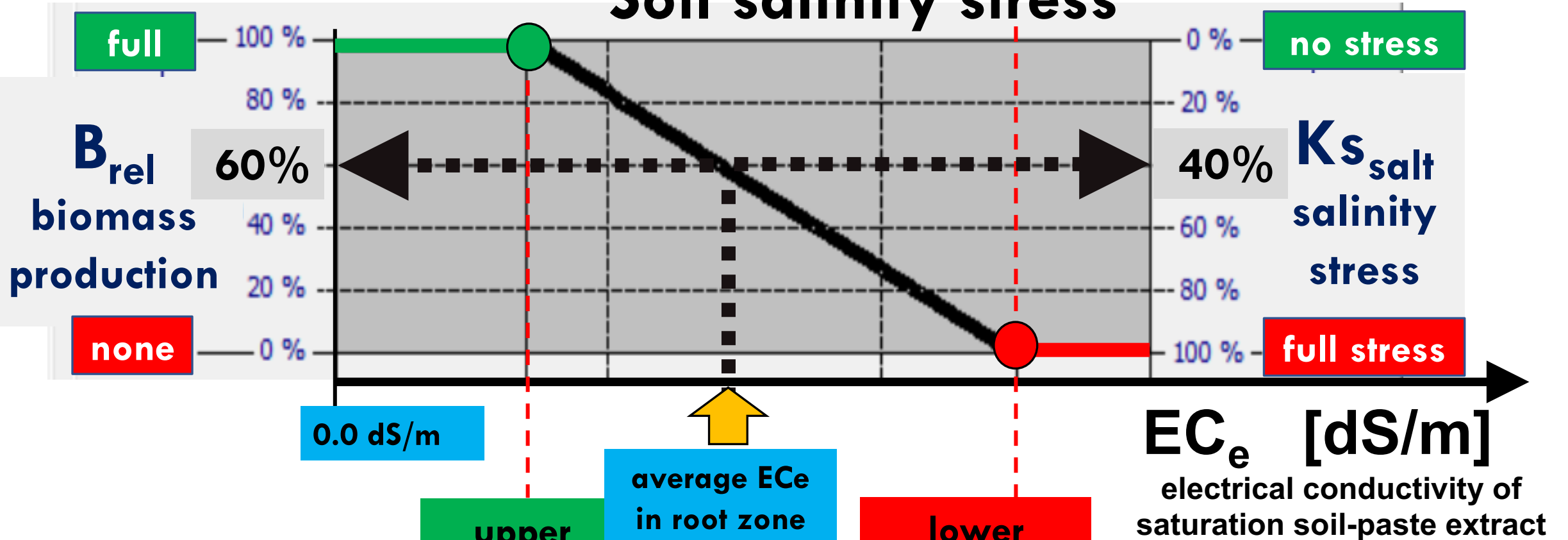
Crop	upper threshold	lower threshold	
Beans	1	6	Extremely sensitive
Rice	3	11	Sensitive

Soil salinity stress

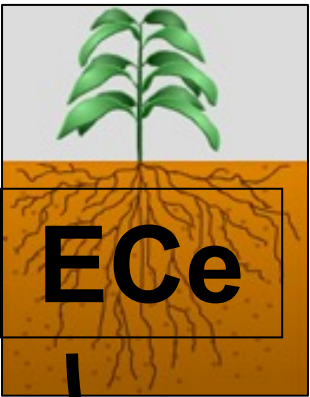


Crop	upper threshold	lower threshold	
Beans	1	6	Extremely sensitive
Rice	3	11	Sensitive
Wheat	6	20	Moderately tolerant

Soil salinity stress

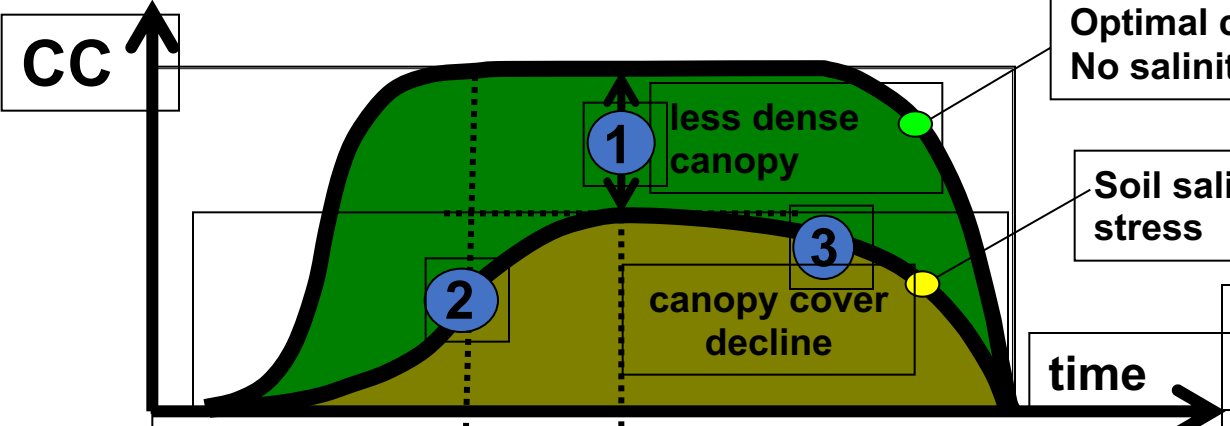


Crop	upper threshold	lower threshold	
Beans	1	6	Extremely sensitive
Rice	3	11	Sensitive
Wheat	6	20	Moderately tolerant
Cotton	8	28	Tolerant



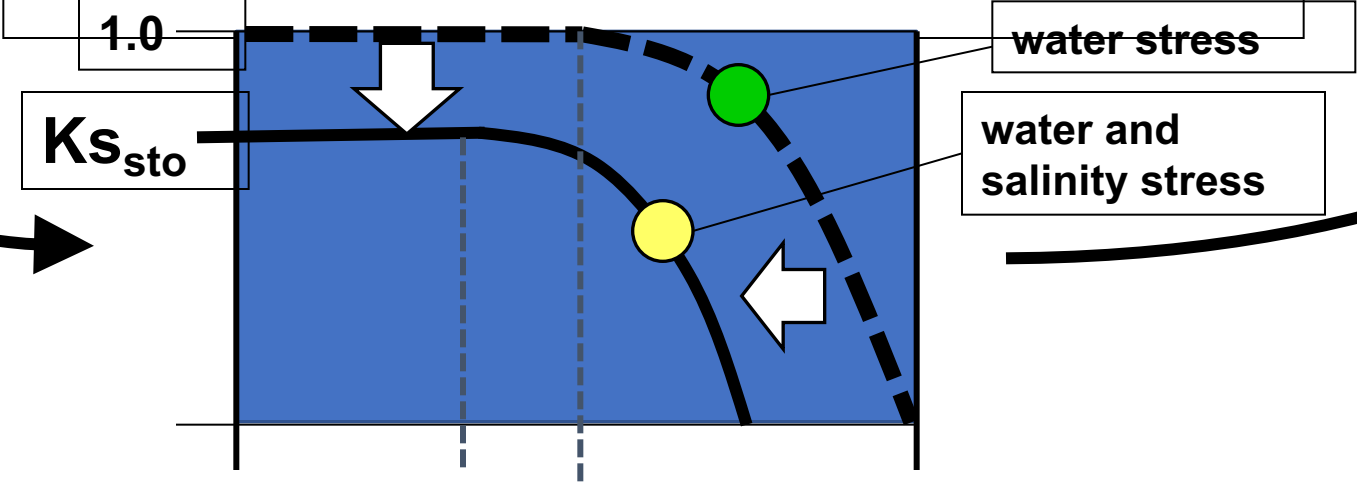
Effects of soil salinity stress:
– smaller canopy cover (CC)

Ks_{salt}
salt
salinity
stress



less biomass ← **B** = $WP^* \times \Sigma \left(\frac{Tr}{ET_0} \right)$

– triggering of stomatal closure
less yield



– triggering of stomatal closure

water stress

water and salinity stress

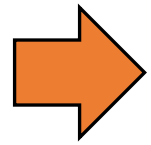
less transpiration



Contents

Theoretical aspects

Simulation of soil salinity in AquaCrop

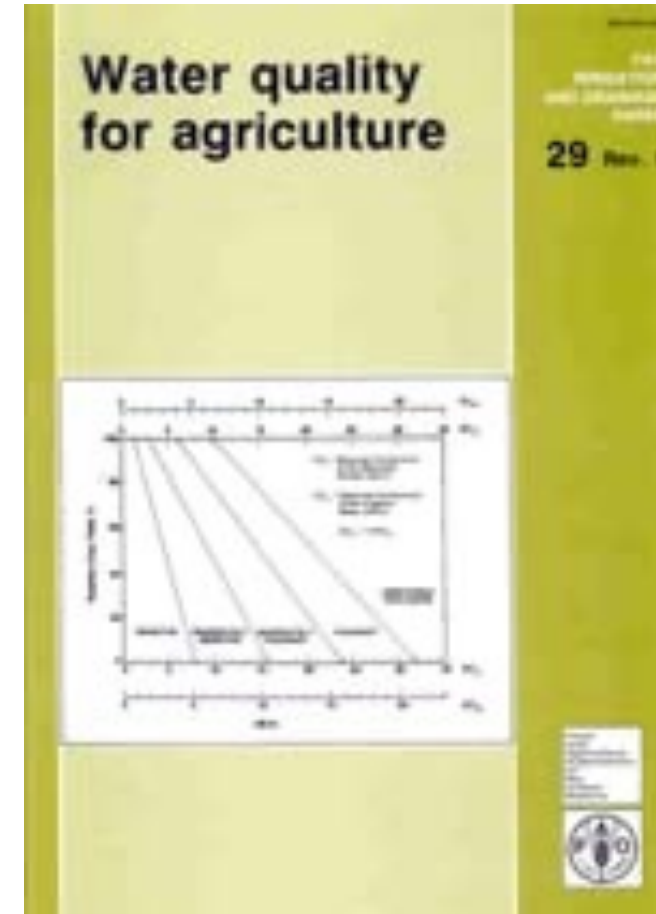


▪ Evaluation of the salt balance

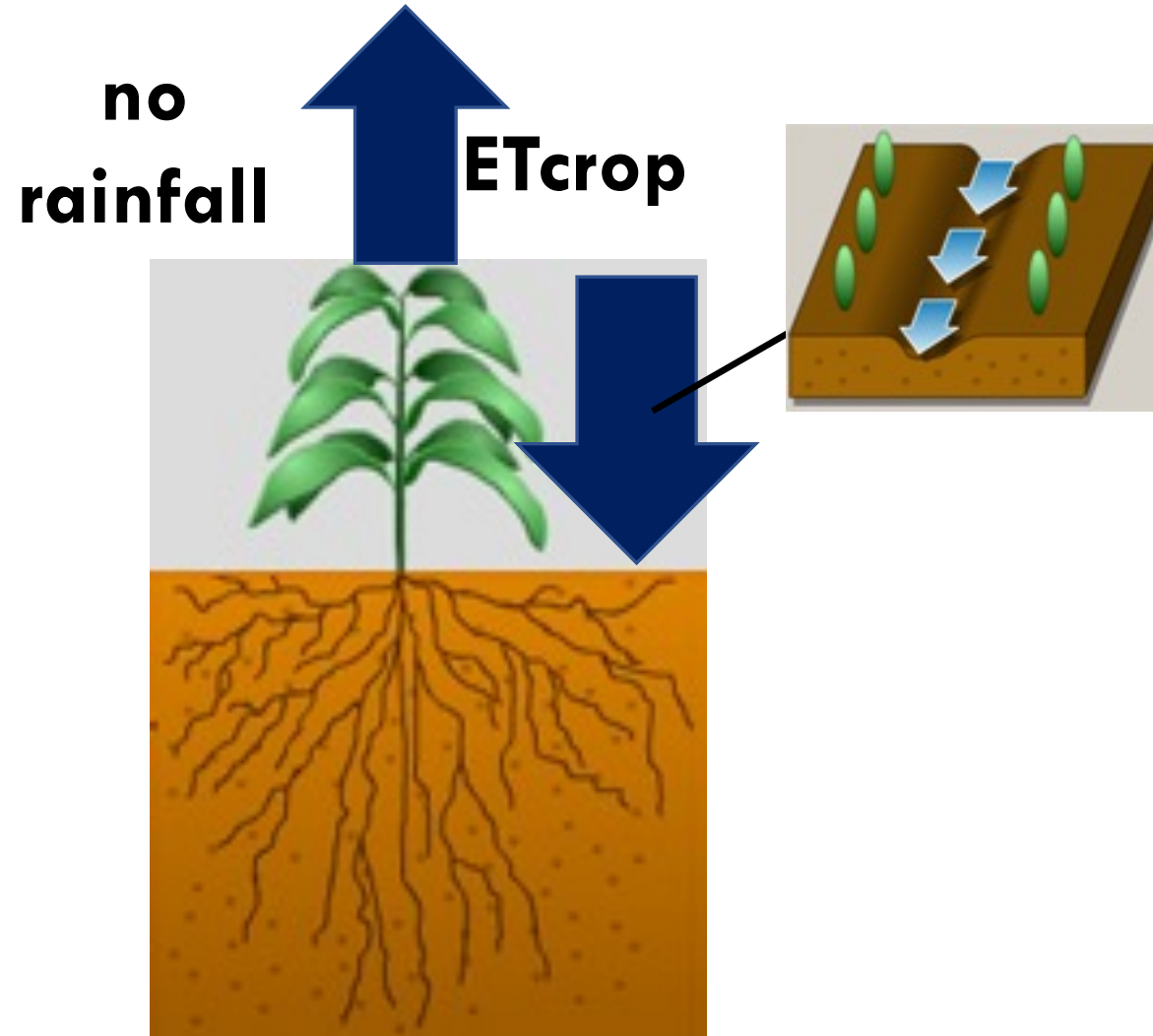
Ayers and Westcot. 1985.

Water quality for agriculture.

FAO Irrigation and Drainage Paper N° 29



Theoretical calculation of EC_e



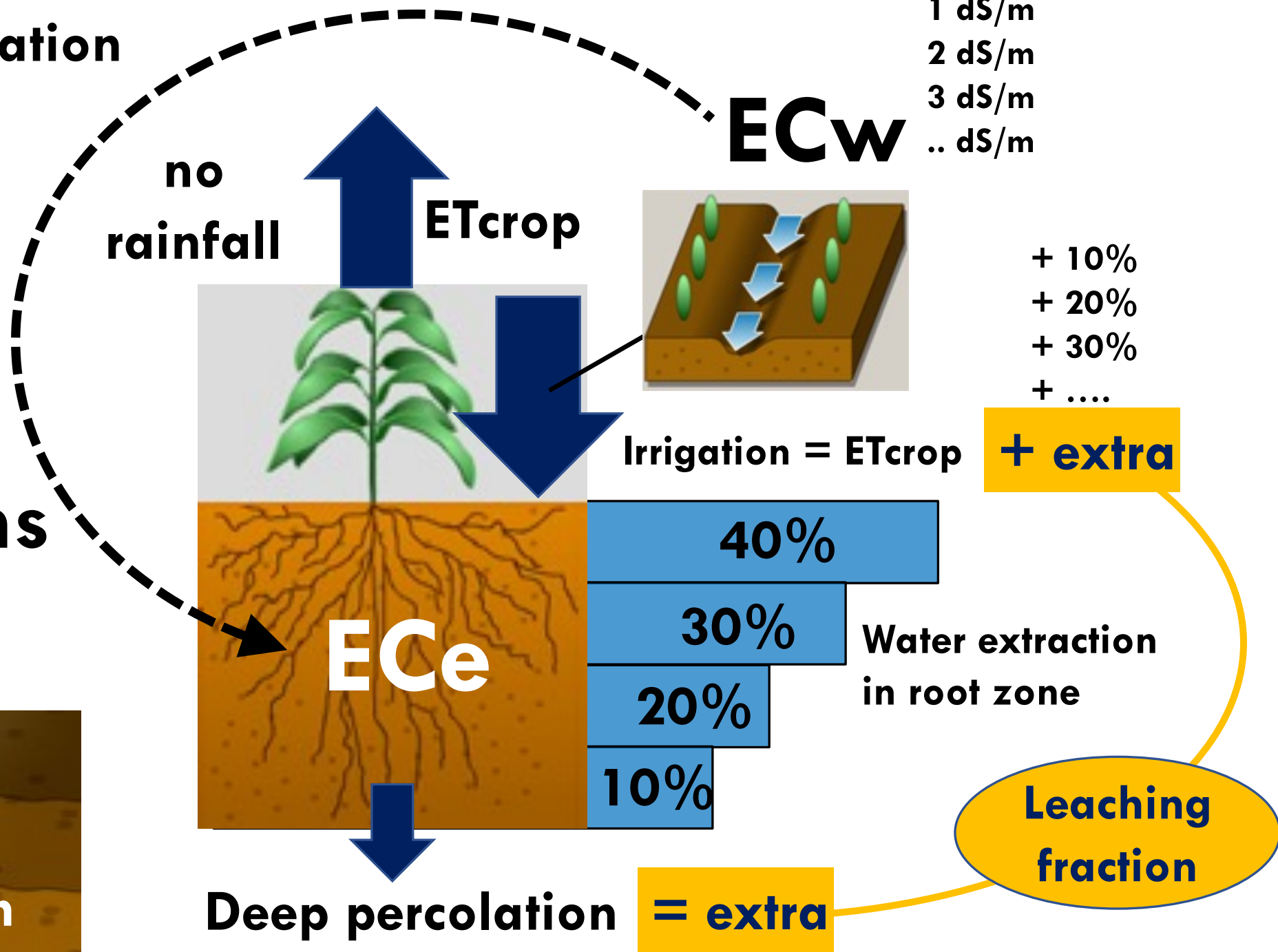
Assumptions

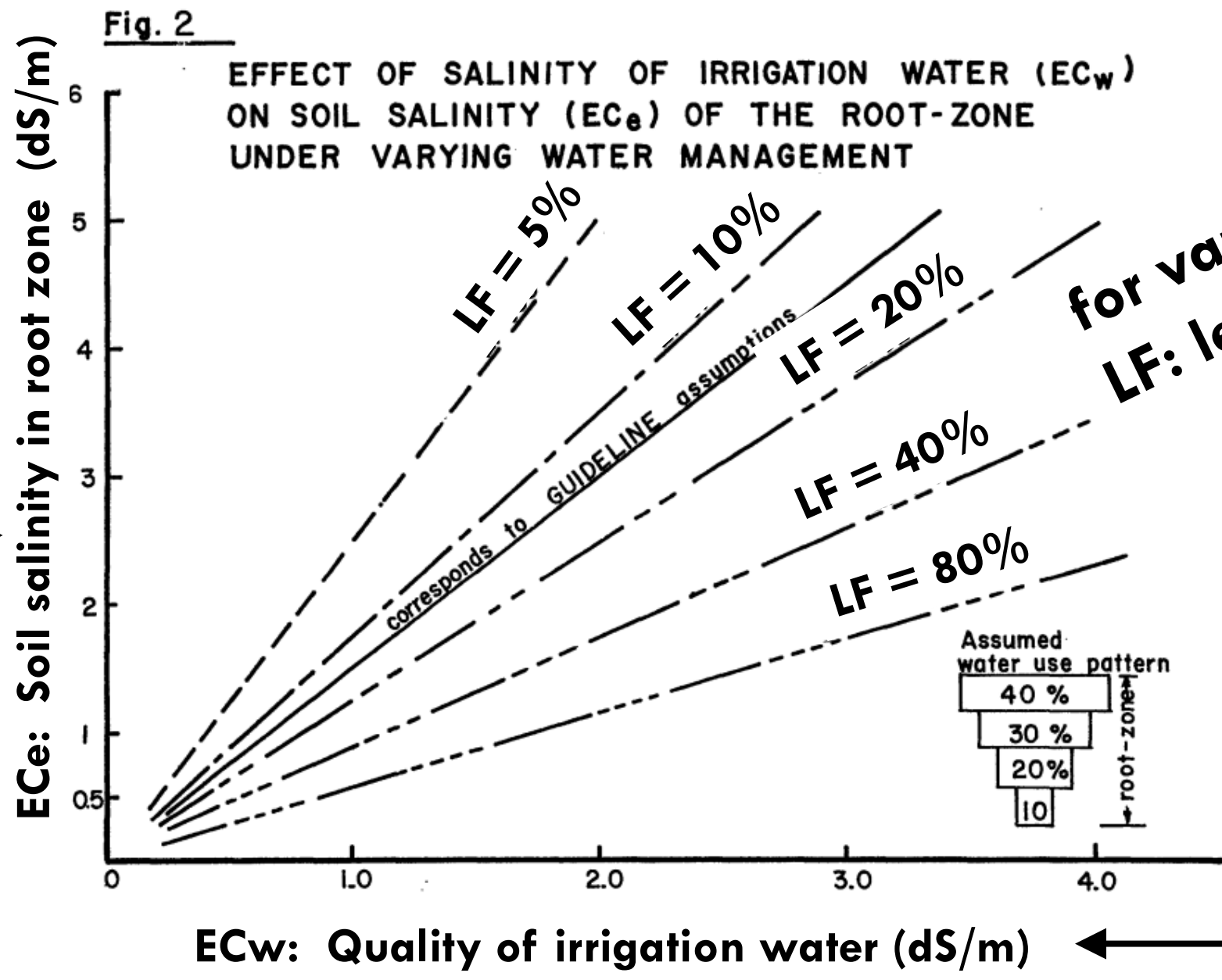
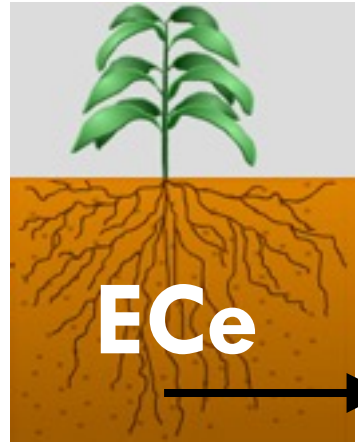
Soil texture:
sandy loam
to clay loam

Theoretical calculation of EC_e

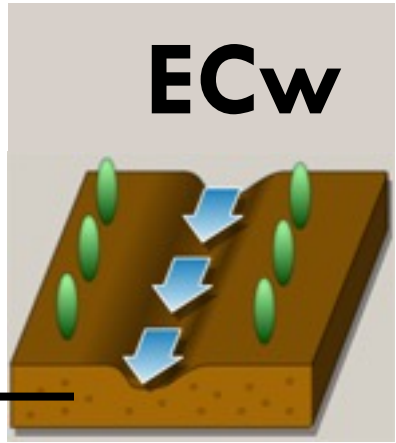
Assumptions

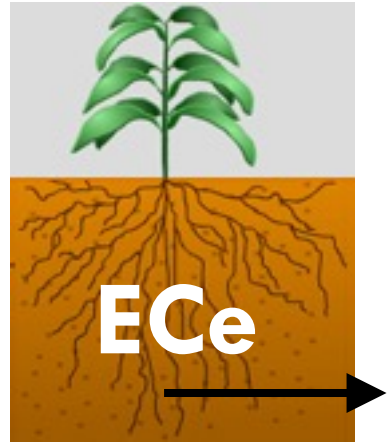
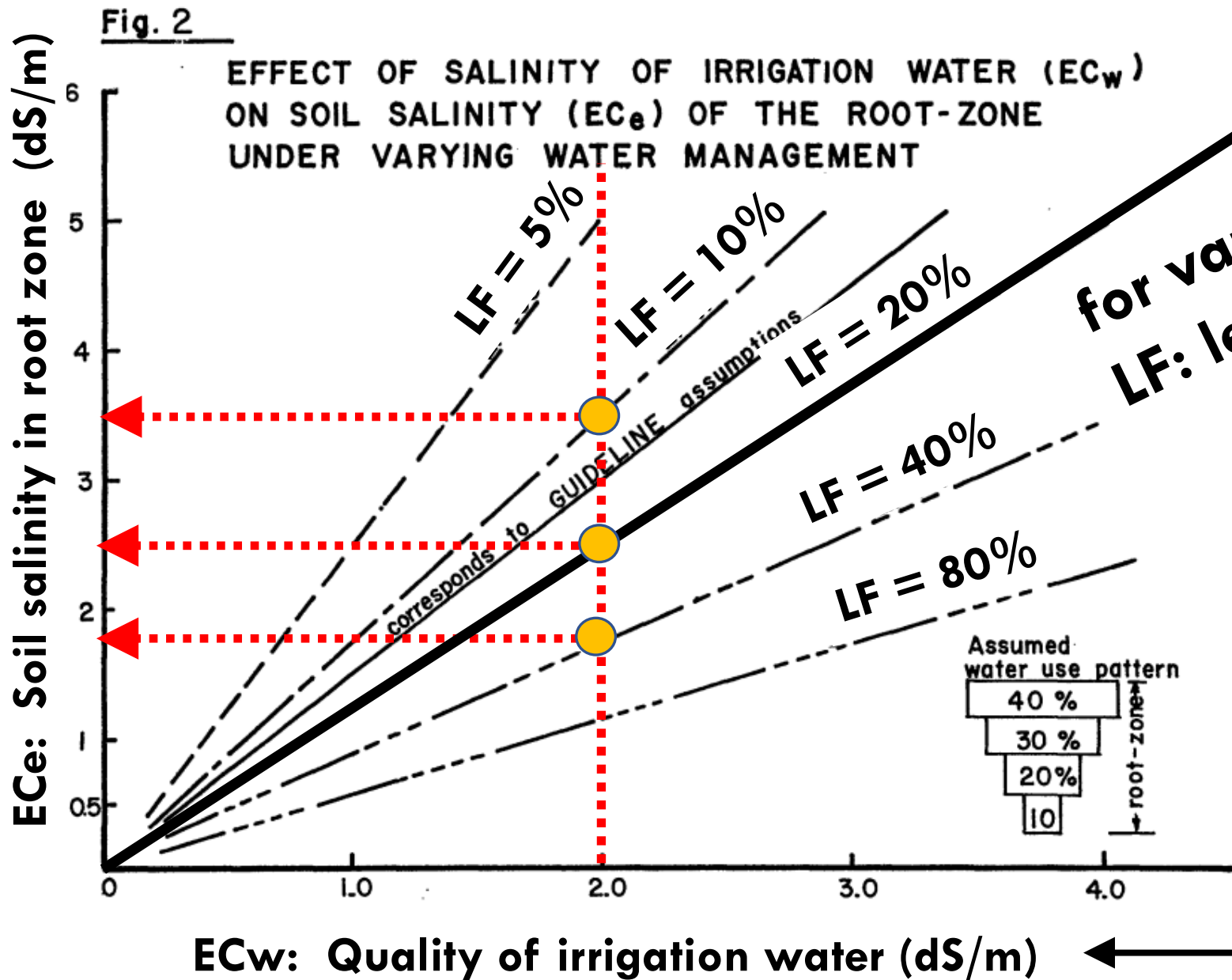
Soil texture:
sandy loam
to clay loam





**Soil texture:
sandy loam
to clay loam**





**Soil texture:
sandy loam
to clay loam**

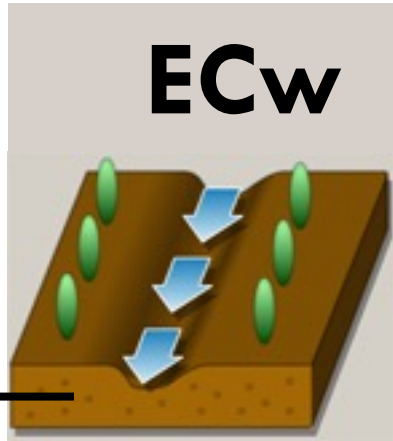

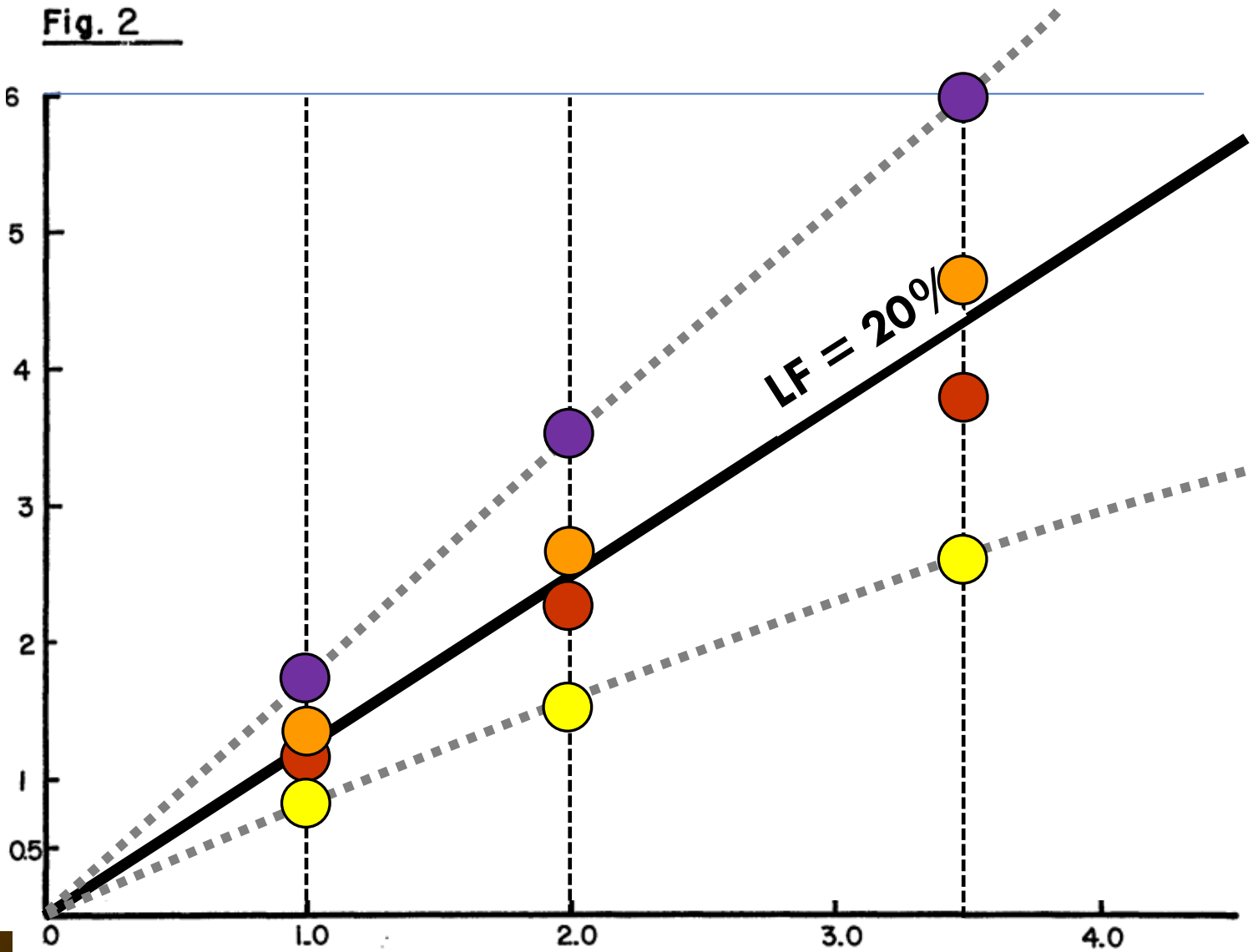


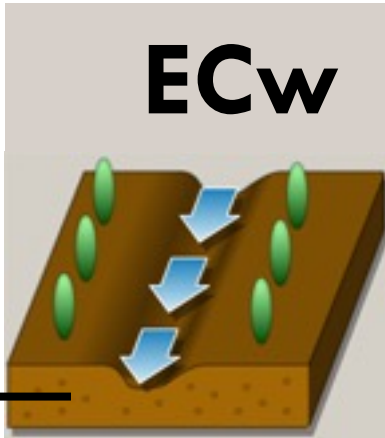
Fig. 2

ECe: Soil salinity in root zone (dS/m)



- Loam
- Sandy loam
- Sand
- Silty clay loam

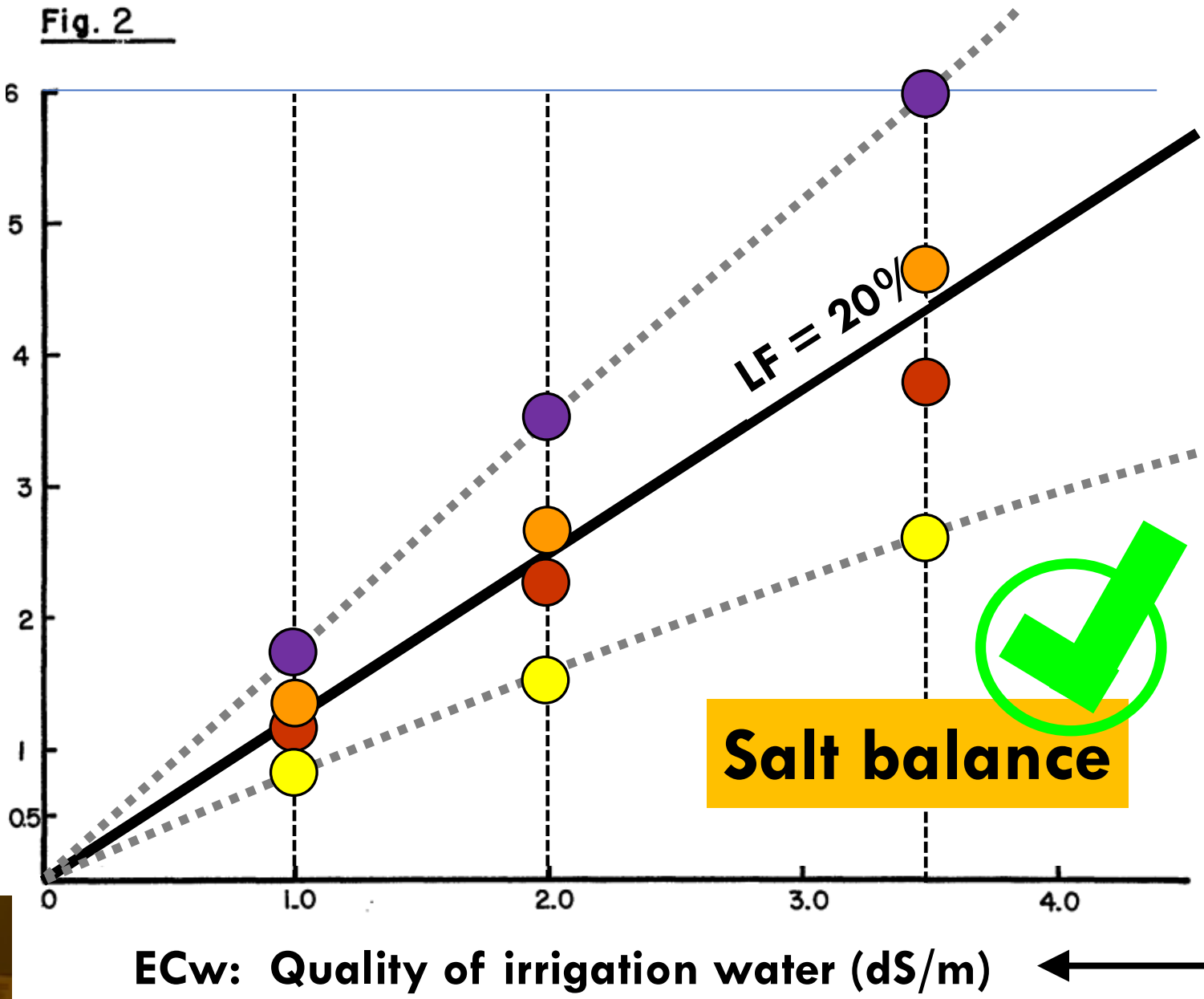
ECw: Quality of irrigation water (dS/m)



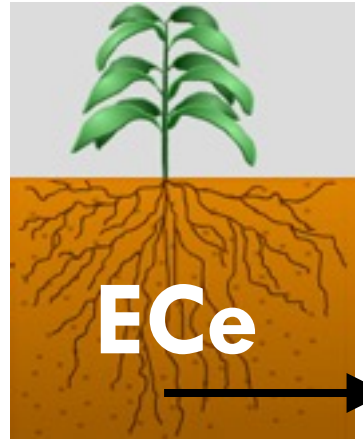
**Soil texture:
sandy loam
to clay loam**

Fig. 2

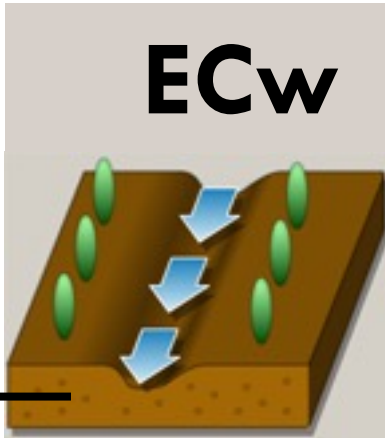
ECe: Soil salinity in root zone (dS/m)



- Loam
- Sandy loam
- Sand
- Silty clay loam



**Soil texture:
sandy loam
to clay loam**





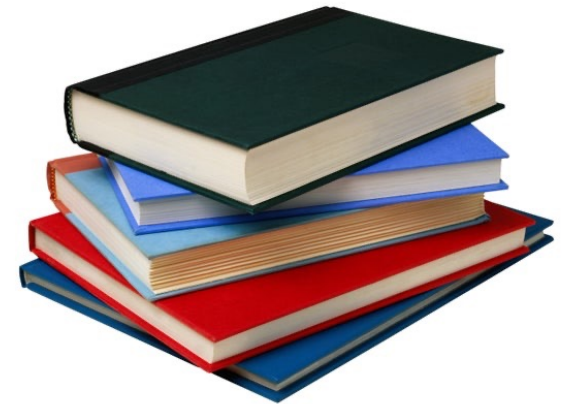
Contents

Theoretical aspects

- Simulation of soil salinity in AquaCrop
- Evaluation of the salt balance

Applications

- ➔ ▪ Crop production under saline conditions



scientific papers



North China plain

Zhai, Y. et al. 2022.

Evaluation and Application of the AquaCrop Model in Simulating Soil Salinity and **Winter Wheat** Yield under Saline Water Irrigation. *Agronomy*, <https://doi.org/10.3390/agronomy12102313>



Tan, S., et al. 2018,

Performance of AquaCrop model for **cotton** growth simulation under film-mulched drip irrigation in southern Xinjiang, China. *Agricultural Water Management*, 196: 99 – 113



Bangladesh

Mondal, M.S., et al. 2015.

Simulating yield response of **rice** to salinity stress with the AquaCrop model. *Environmental Science: process & Impacts* (6).



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Theoretical aspects

- Simulation of soil salinity in AquaCrop
- Evaluation of the salt balance

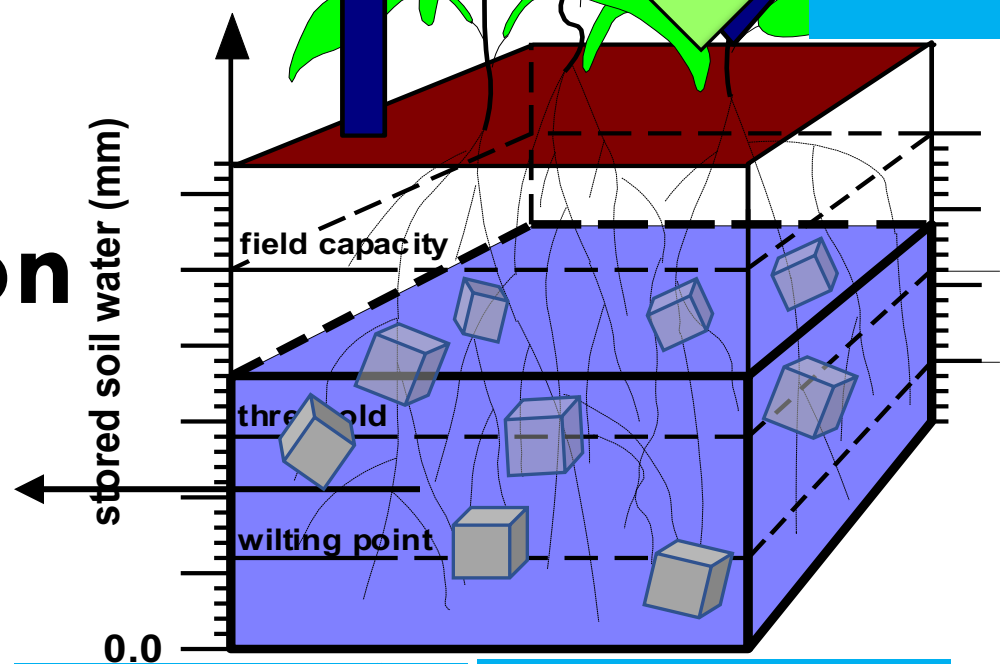
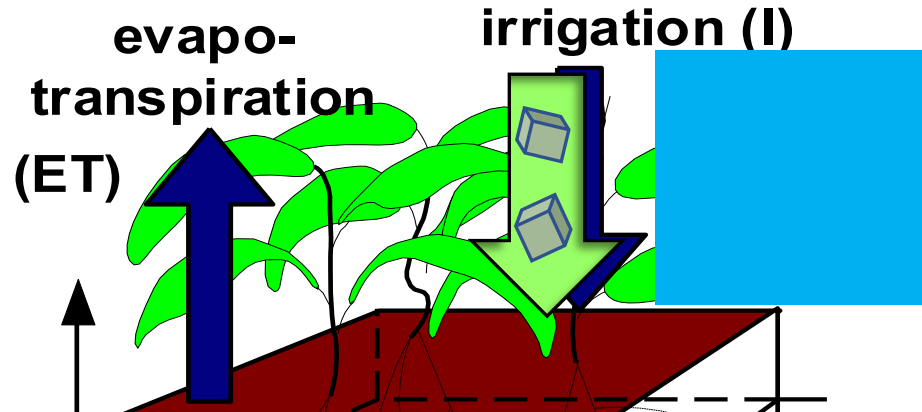
Applications

- Crop production under saline conditions
- ➔ ▪ Leaching by winter rains

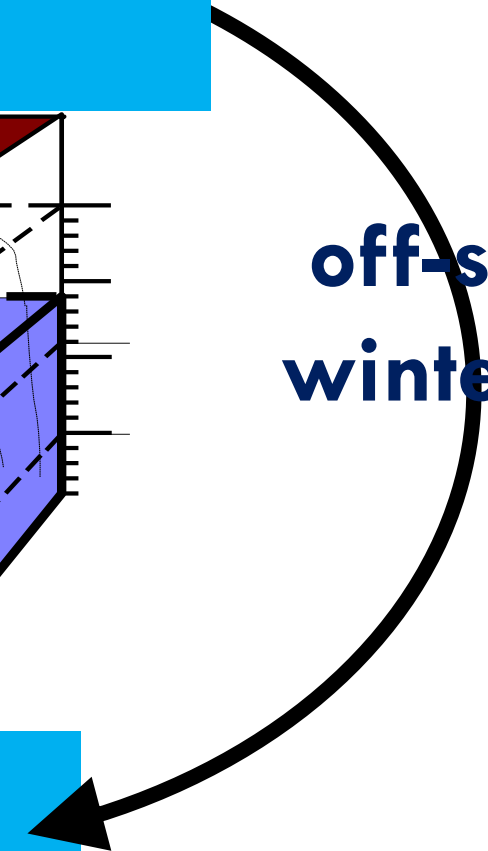


Irrigation season

$$\text{Irrigation} = \text{ET}_{\text{crop}}$$



off-season
winter rains



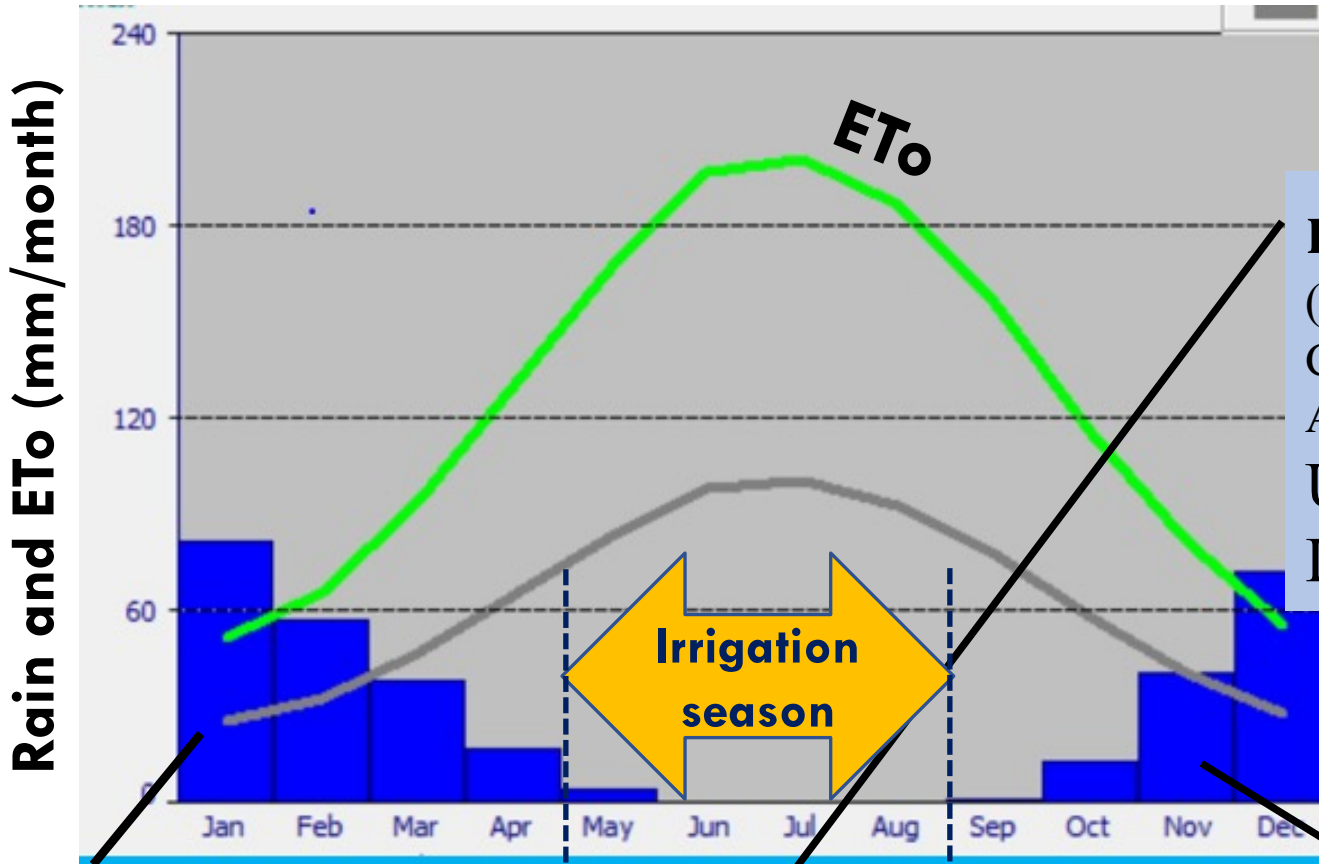
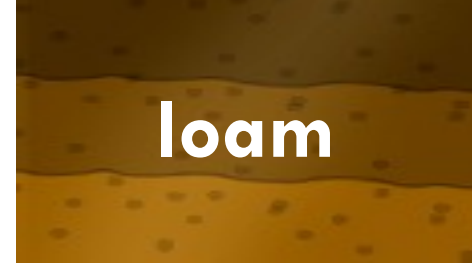
Salt removal

Salt accumulation

Salt
content
[ton/ha]

Rammalah
(Palestine autonomous region)

Ramallah (Palestine autonomous region)



moderate sensitive to salinity stress
(such as Squash, peppers, Lettuce, Potato, Maize, Cabbage, Spinach, Radishes, Cucumber, Broccoli, Tomato, Alfalfa, cauliflower, Berseem)
Upper ECe threshold: 2 dS/m
Lower ECe threshold: 12 dS/m

Rain

Irrigated crop



is the leaching of salts by winter rains sufficient to maintain high crop yields ?

Irrigation strategy

No leaching (Irrigation = ET_{crop})

40 mm irrigation when 100% RAW is depleted

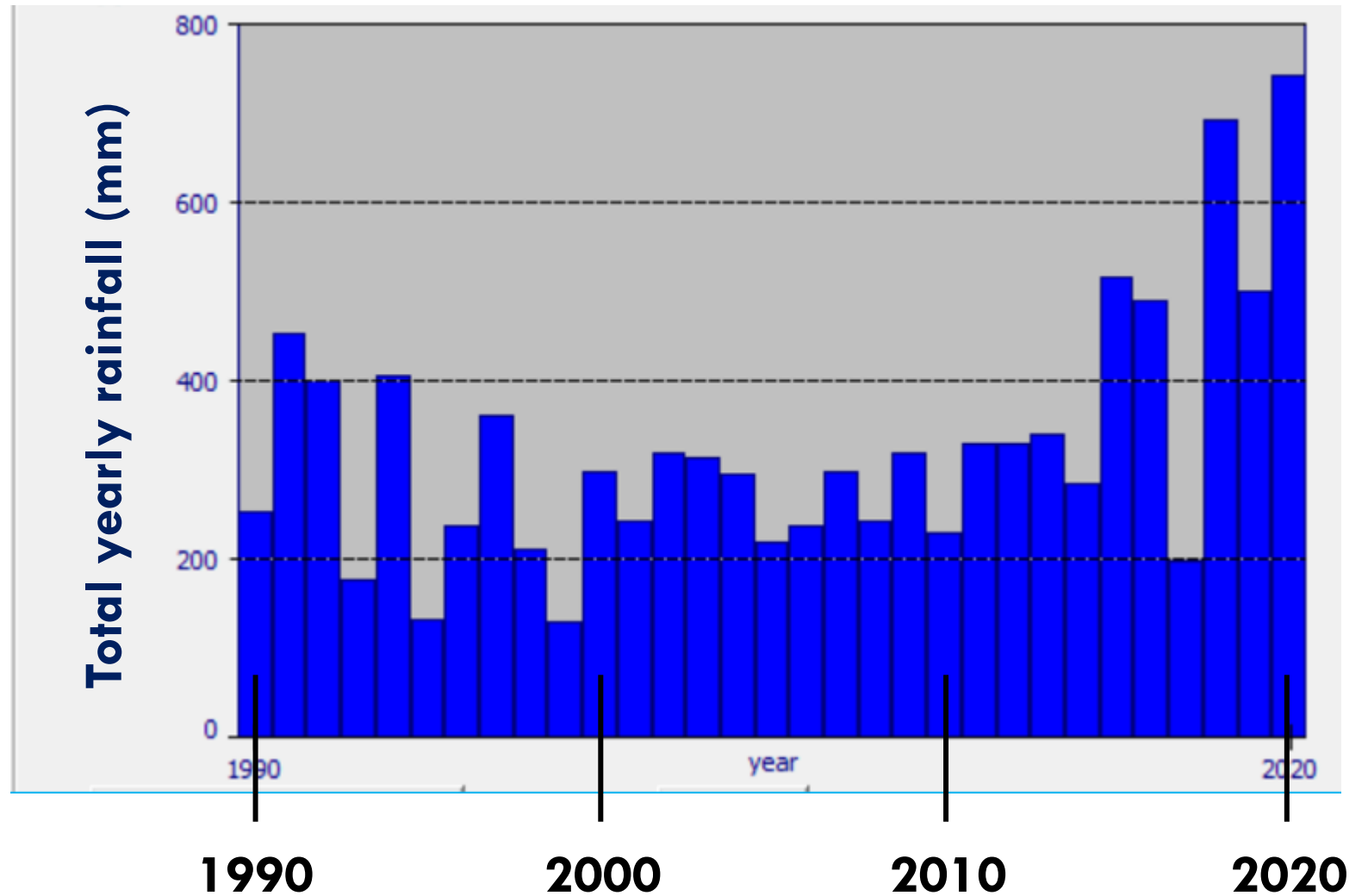
$EC_w = 1.5 \text{ dS/m}$

Ramallah (Palestine autonomous region)



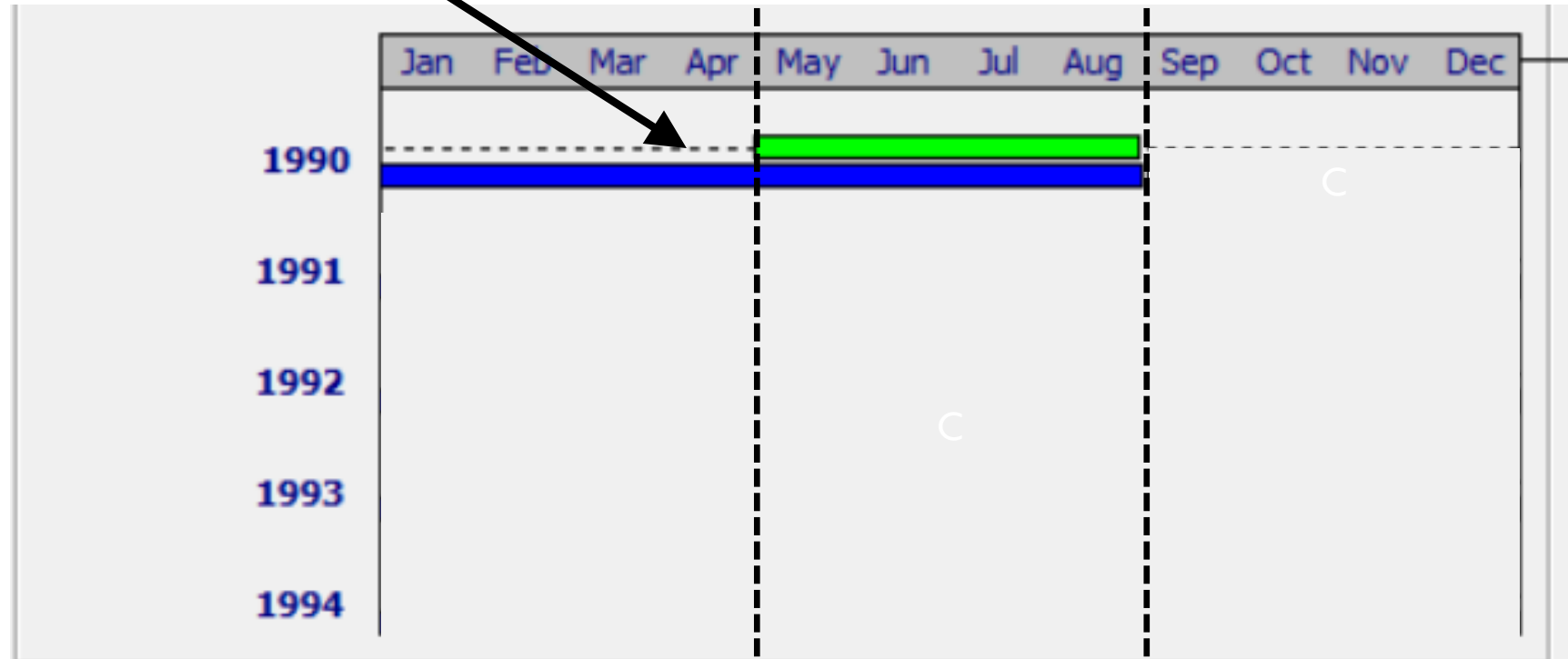
Climatic data: 31 years
daily data: rainfall & ETo



Multiple runs (years)



Ramallah (Palestine autonomous region)

Run 1: from 1 January to 31 Aug 1990

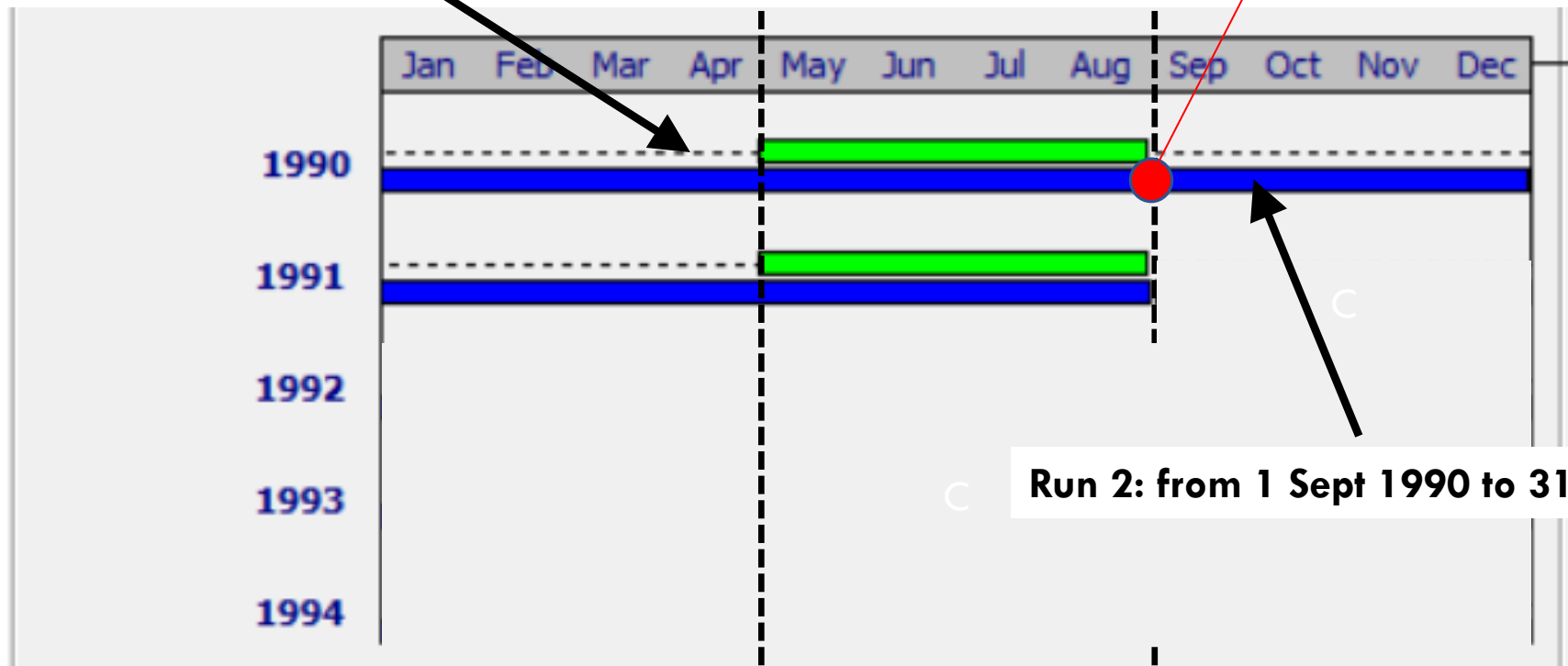


 crop growing cycle
 simulation period¹

**Irrigation
season**



Run 1: from 1 January to 31 Aug 1990



Run 2: from 1 Sept 1990 to 31 Aug 1991



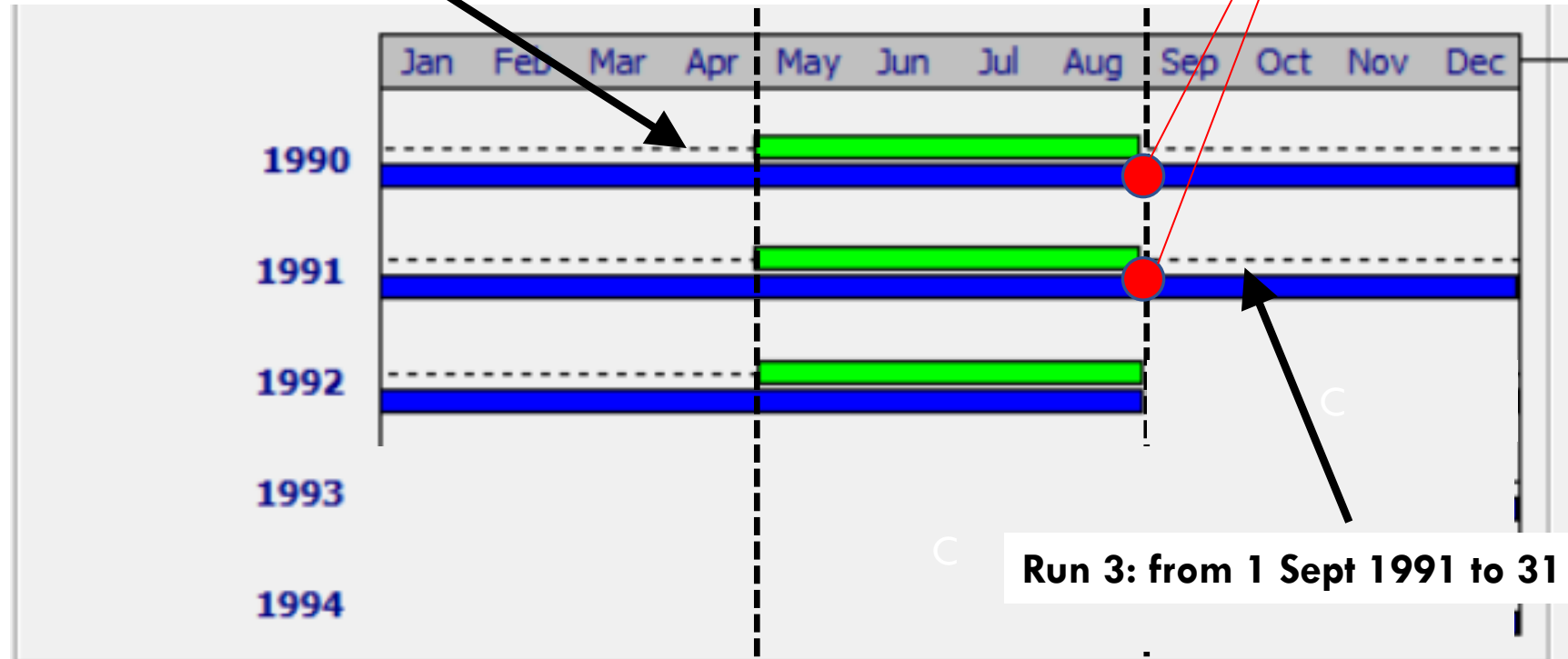
crop growing cycle
simulation period¹

Ramallah (Palestine autonomous region)

Multiple runs (years)

Keep soil water and salt content

Run 1: from 1 January to 1 Sept 1990



Run 3: from 1 Sept 1991 to 31 Aug 1992

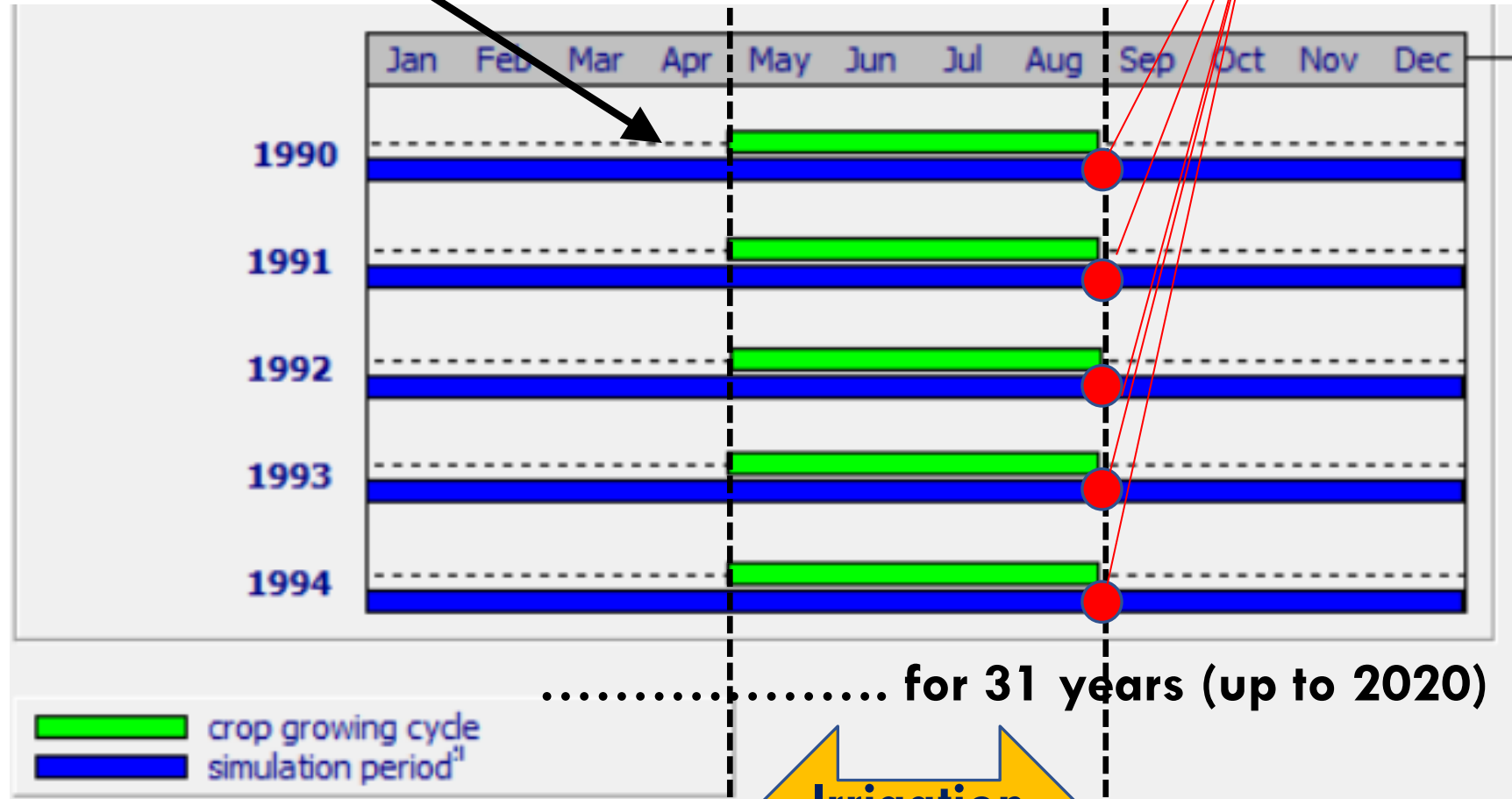
Irrigation season

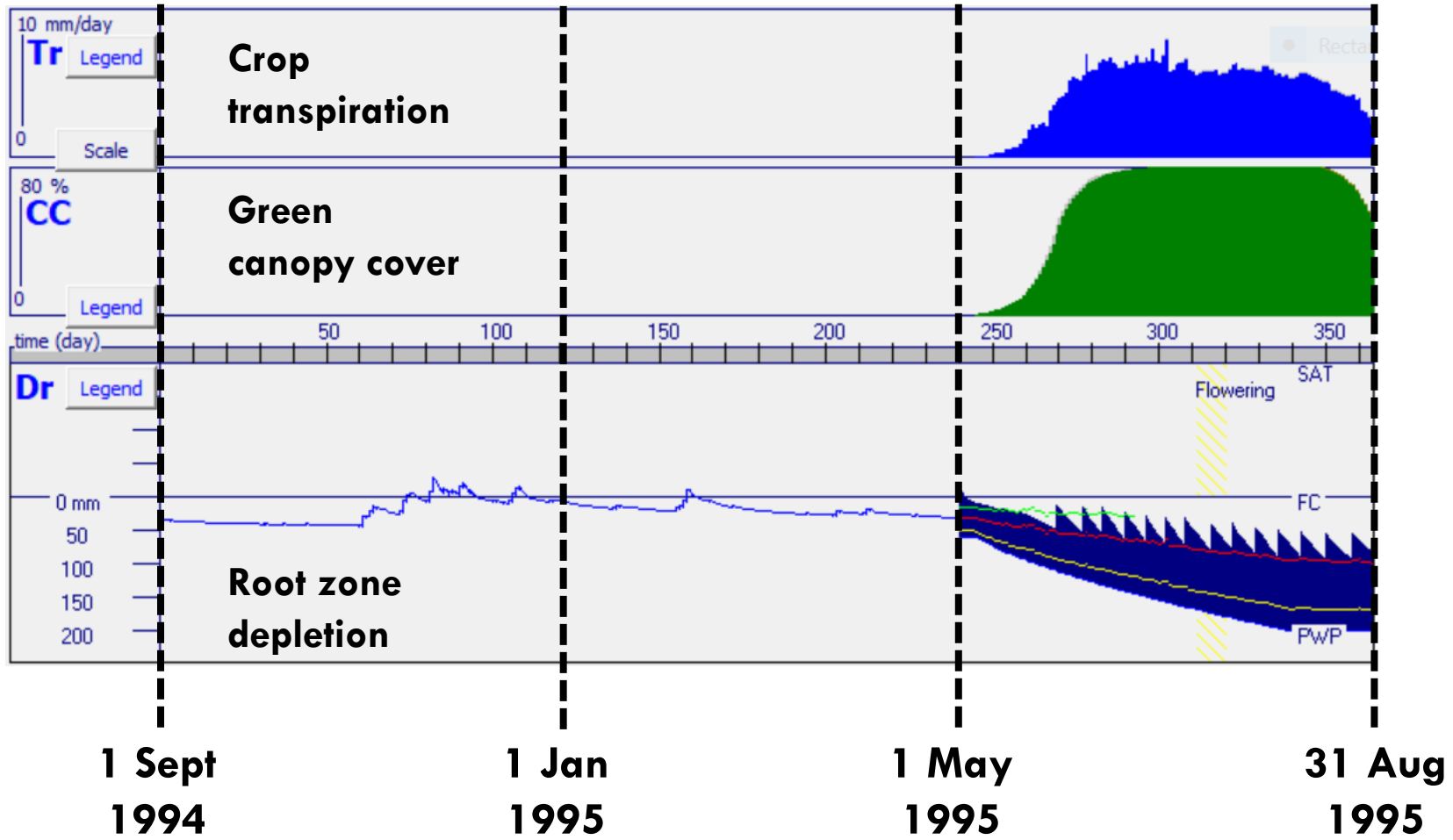
Ramallah (Palestine autonomous region)

Multiple runs (years)

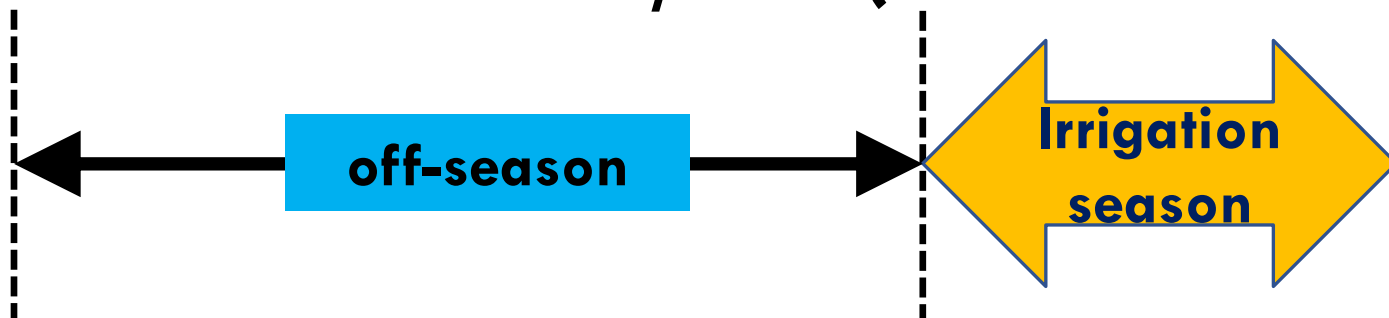
Keep soil water and salt content

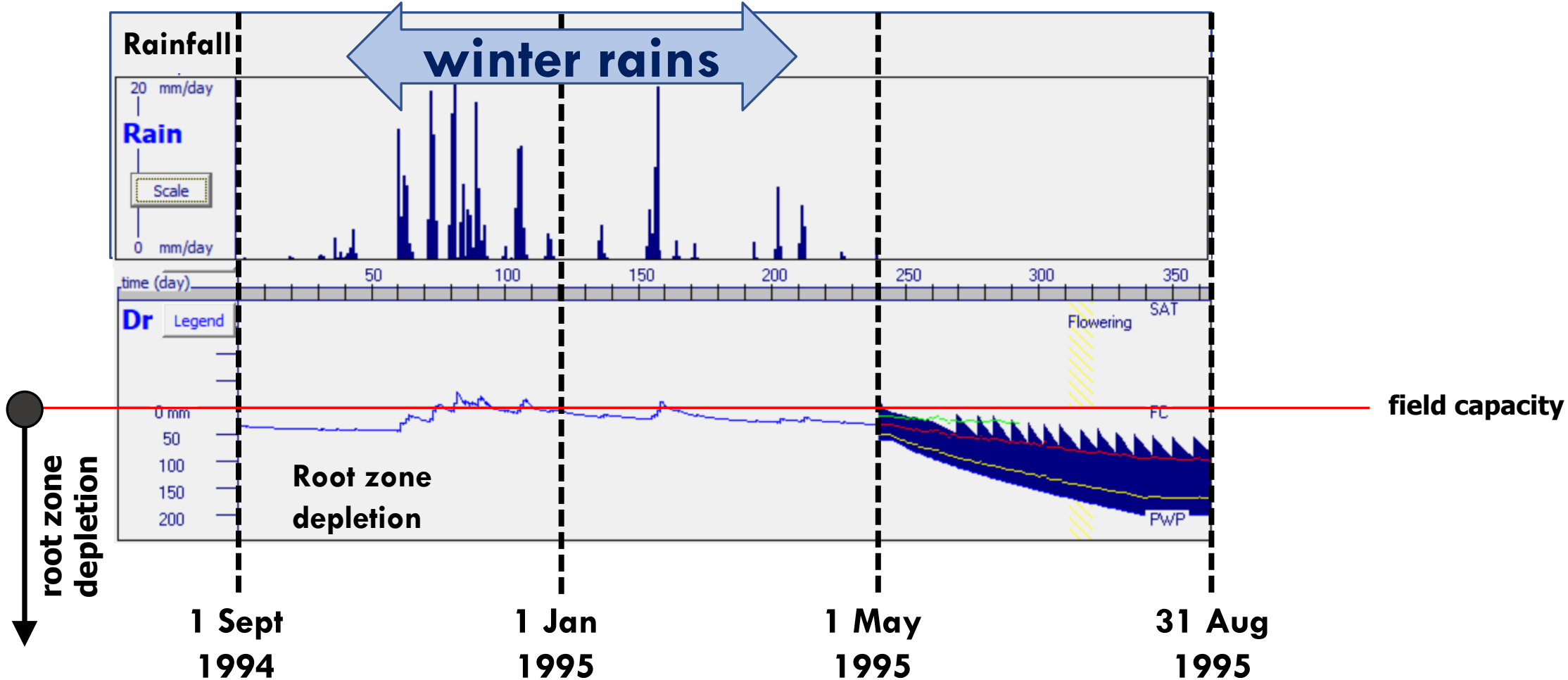
Run 1: from 1 January to 1 Sept 1990



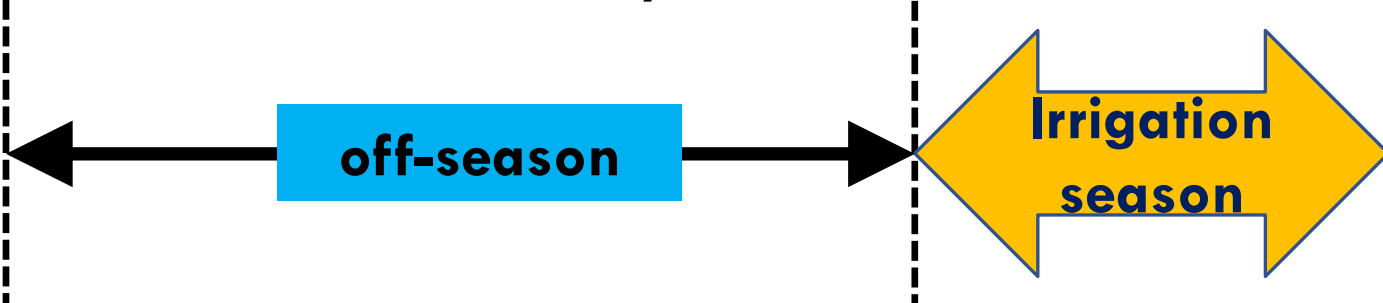


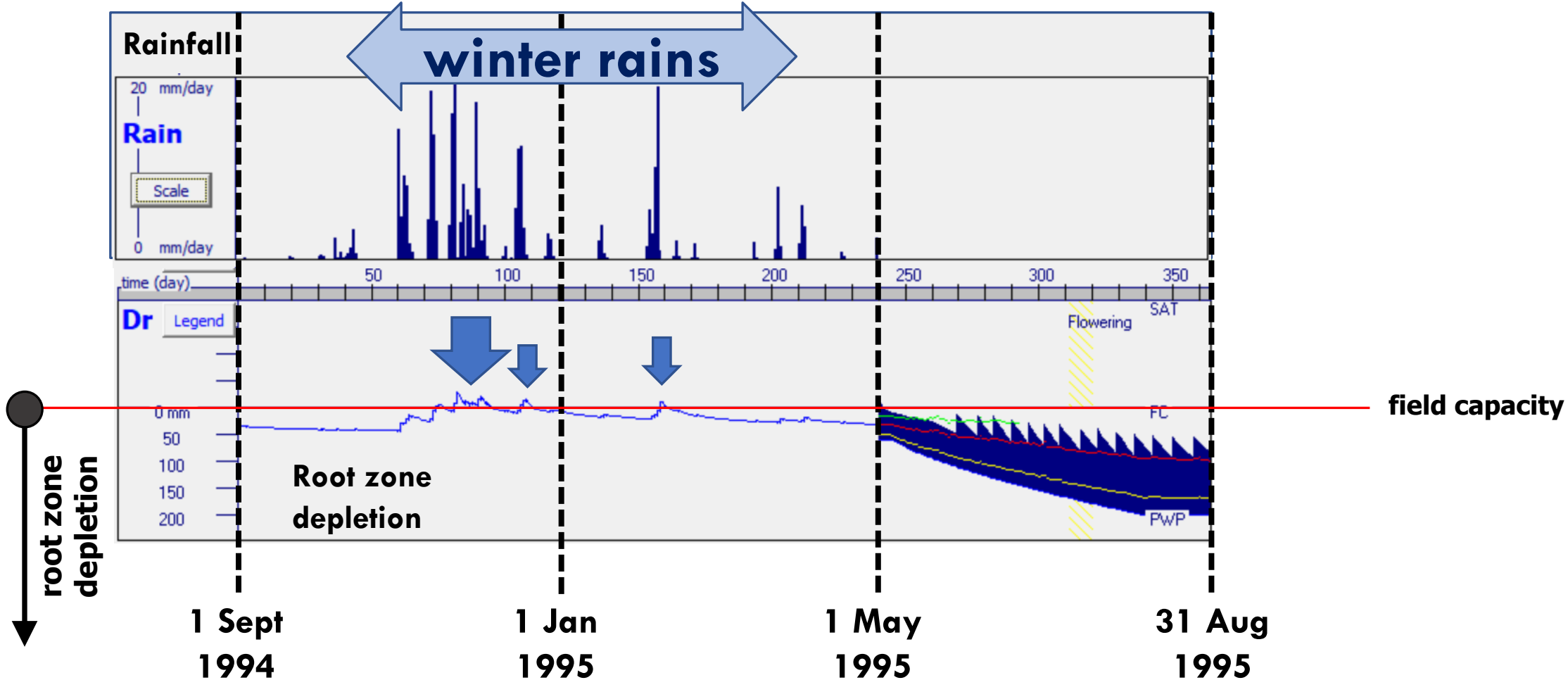
Simulation run 6/31 (1994 – 1995)



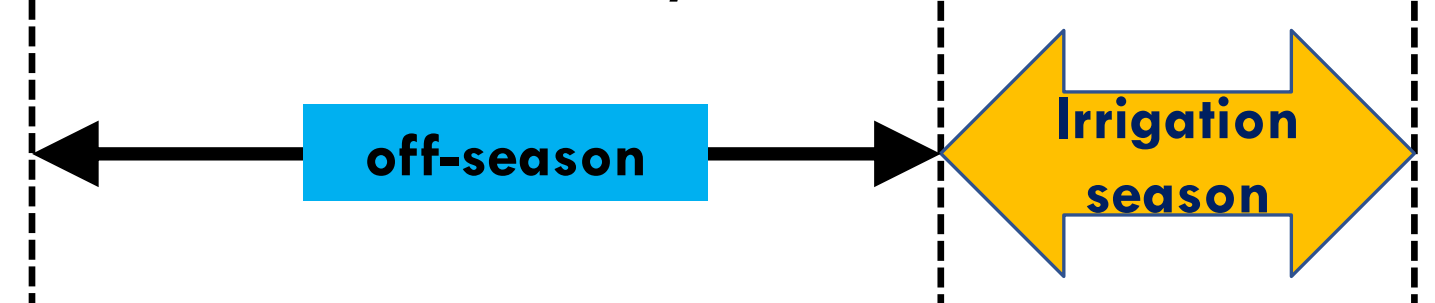


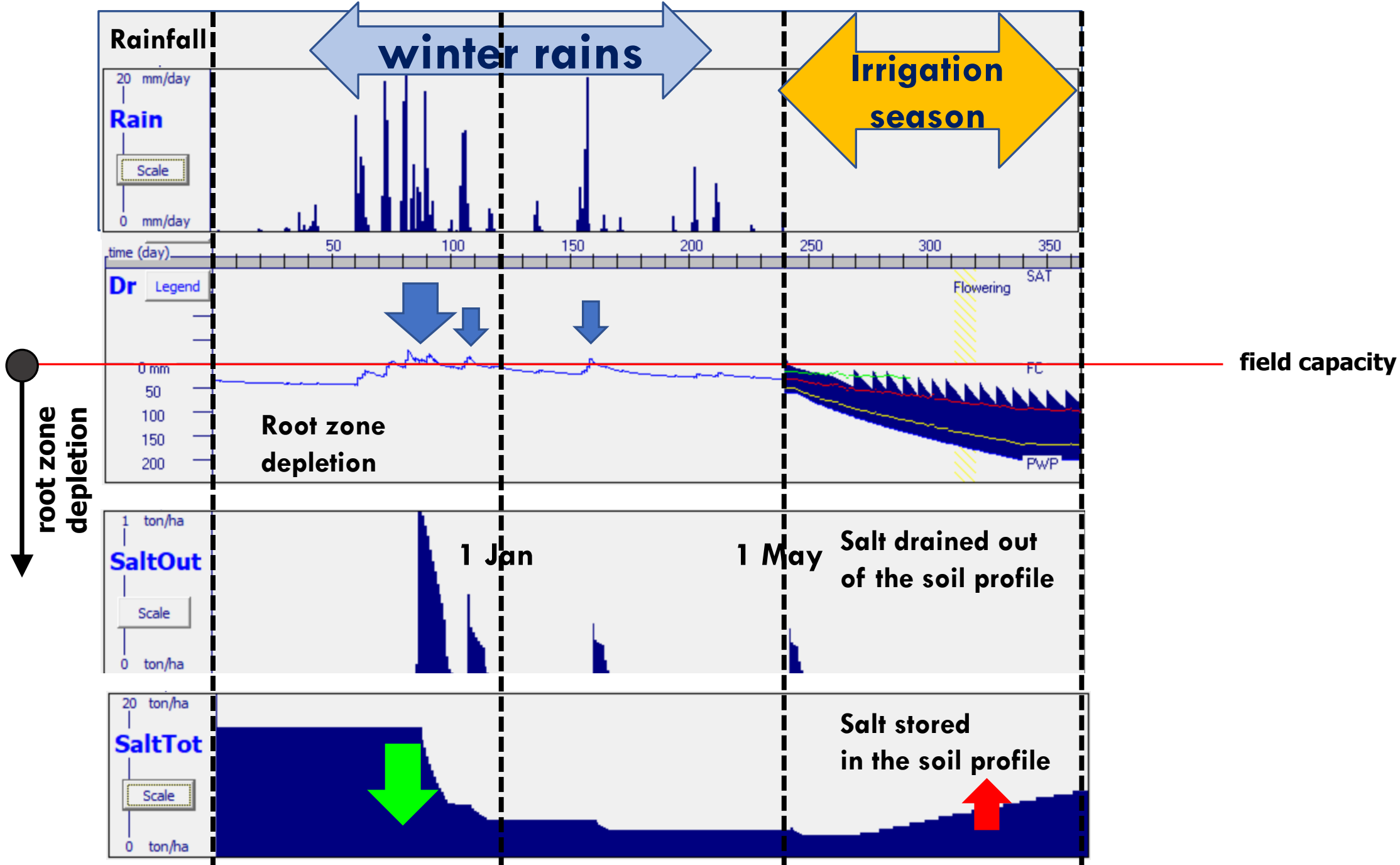
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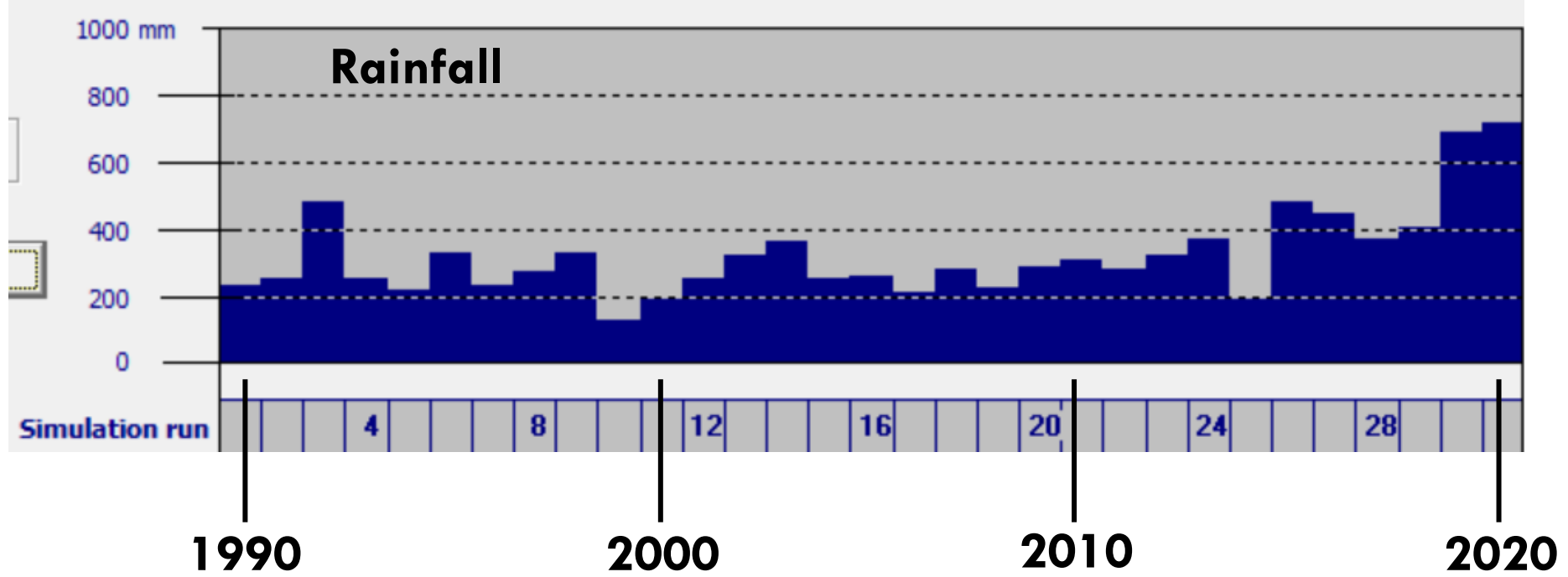


Simulation run 6/31 (1994 – 1995)

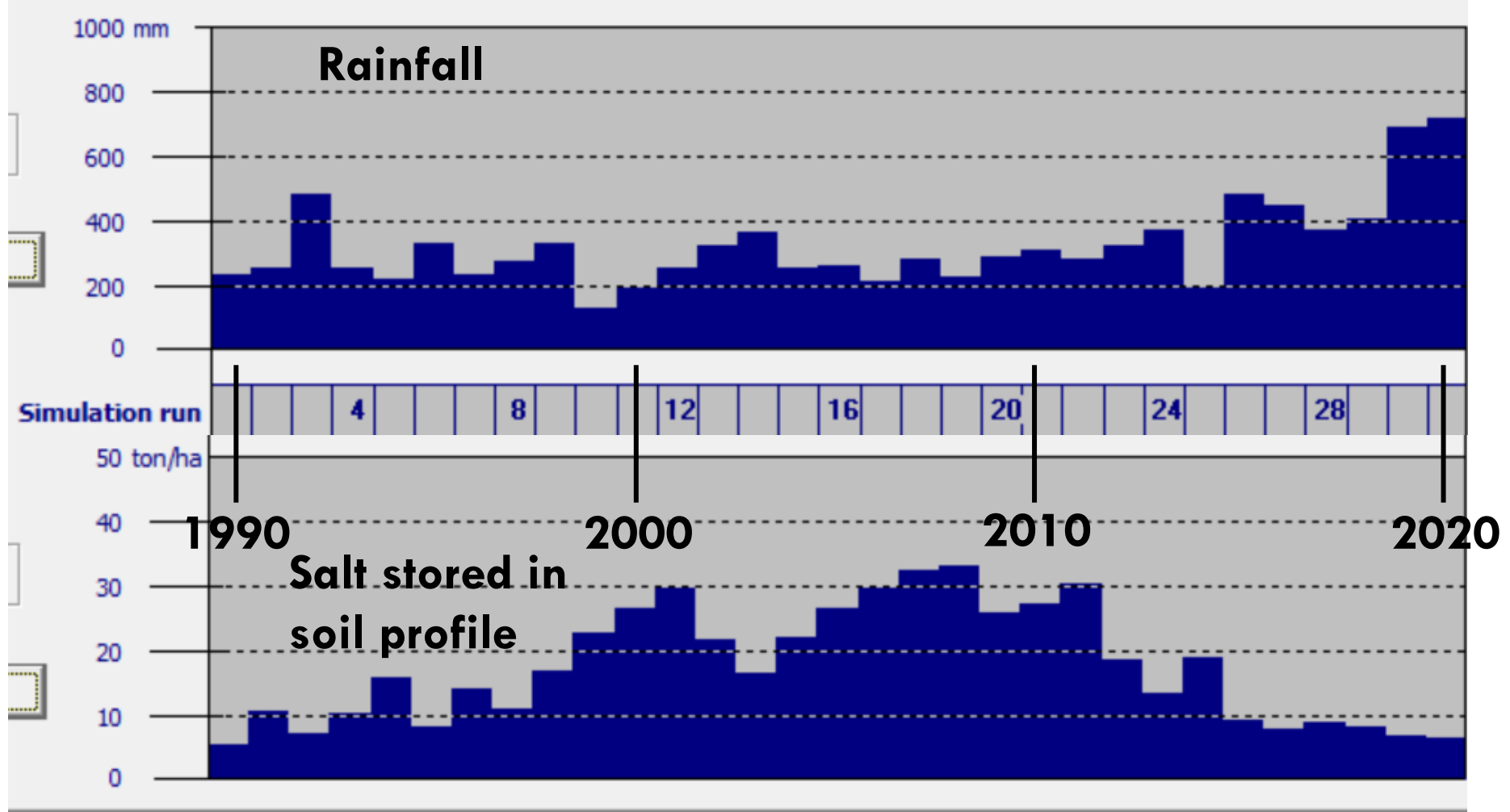


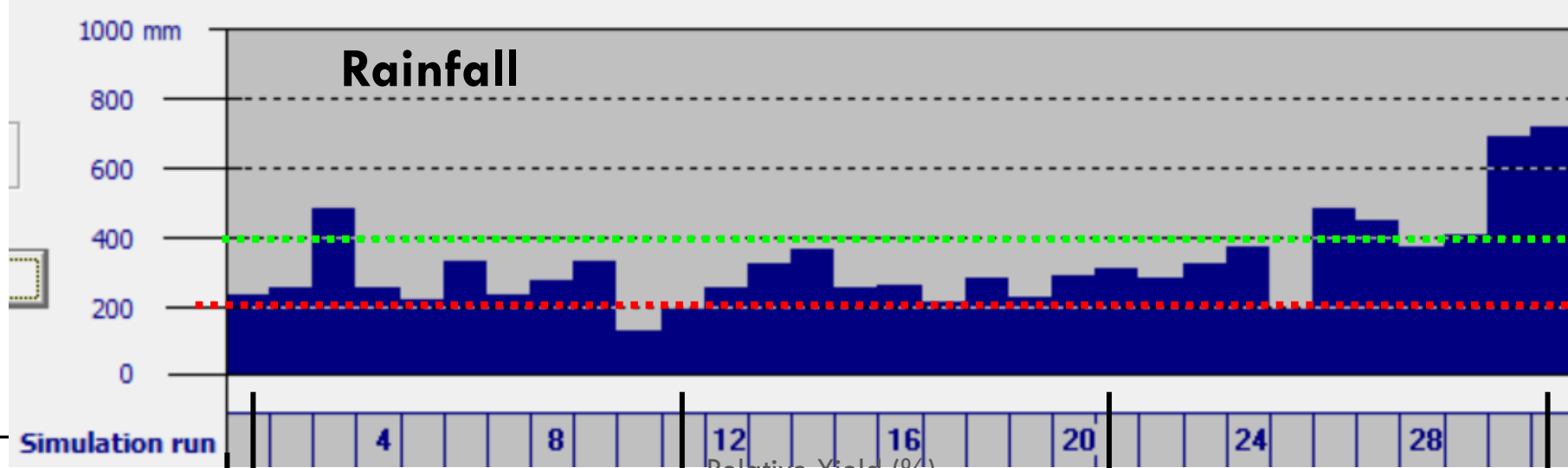


root zone depletion



yearly output (31 years)

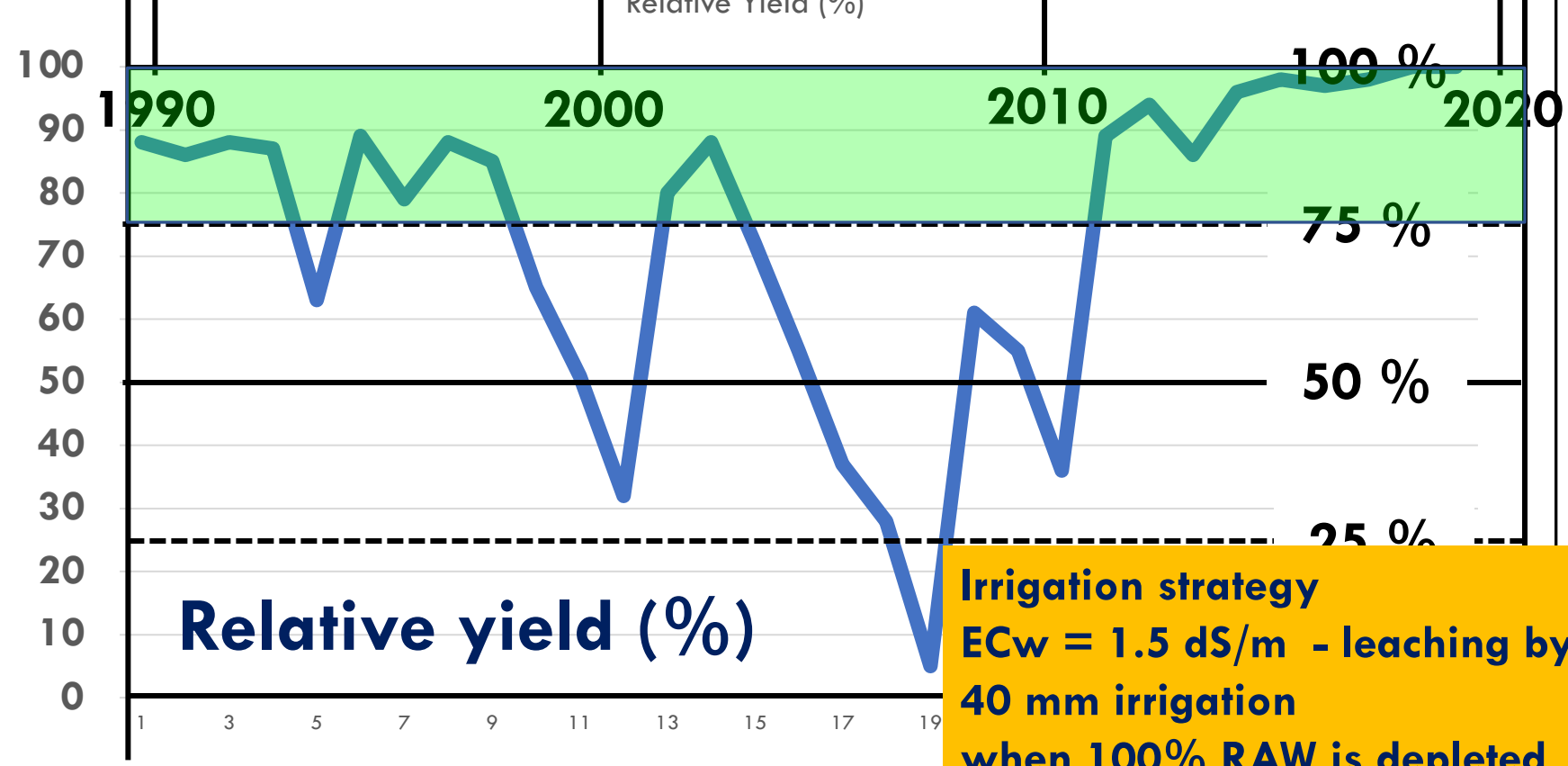




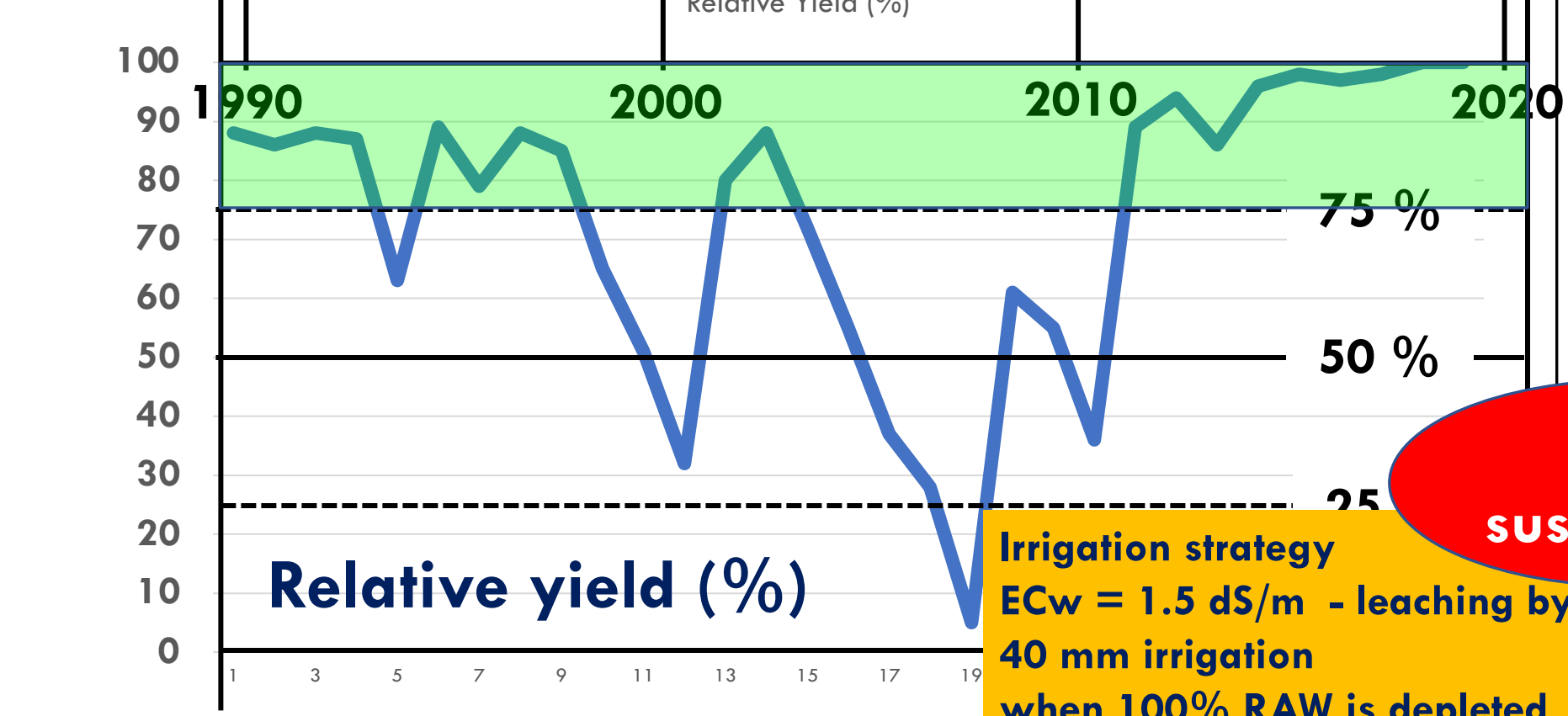
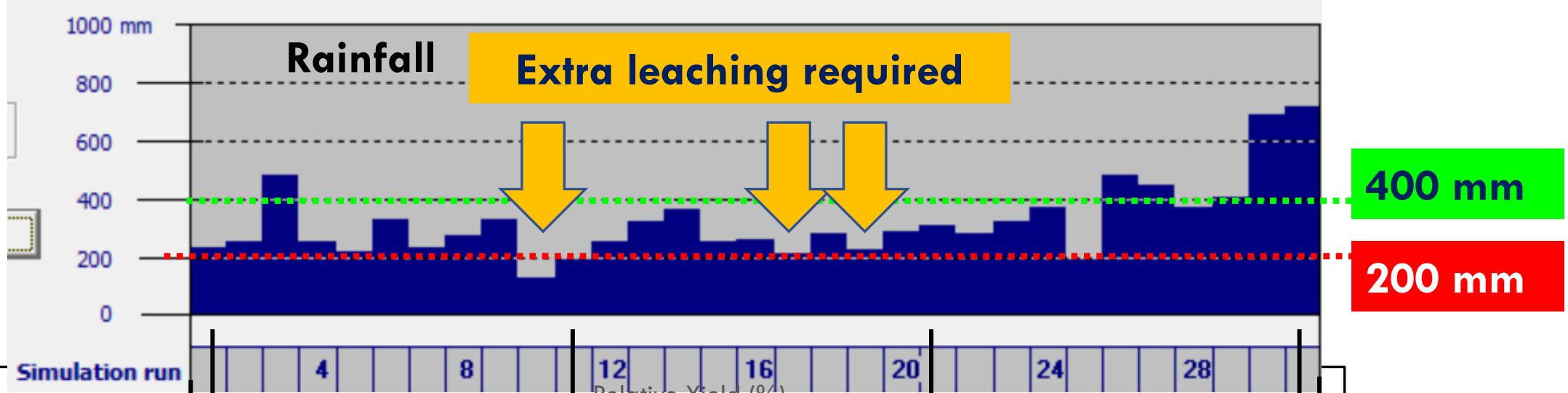
400 mm

200 mm

Simulation run

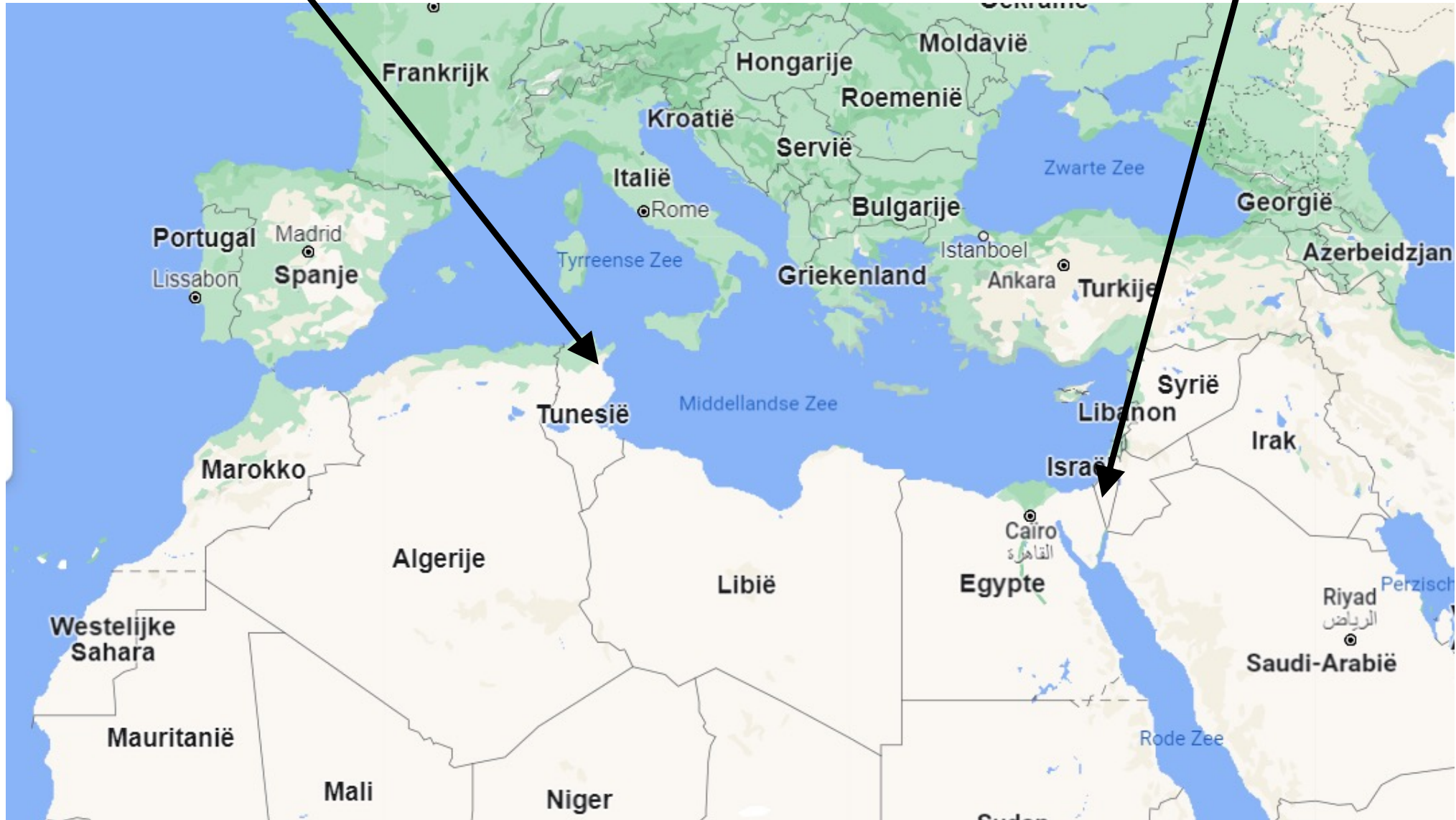


Irrigation strategy
 EC_w = 1.5 dS/m - leaching by winter rains
 40 mm irrigation
 when 100% RAW is depleted

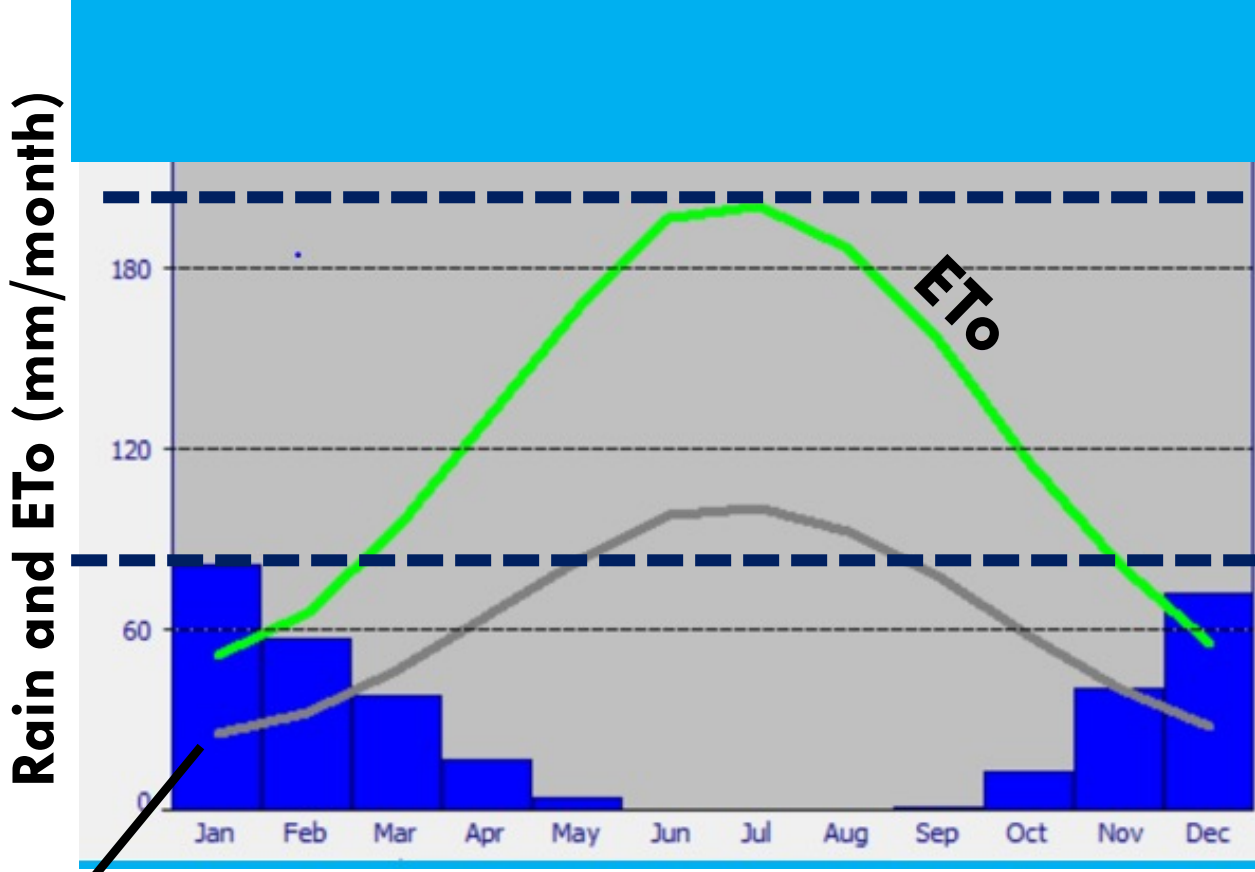


Tunis
(Tunisia)

Ramallah
(Palestine autonomous region)

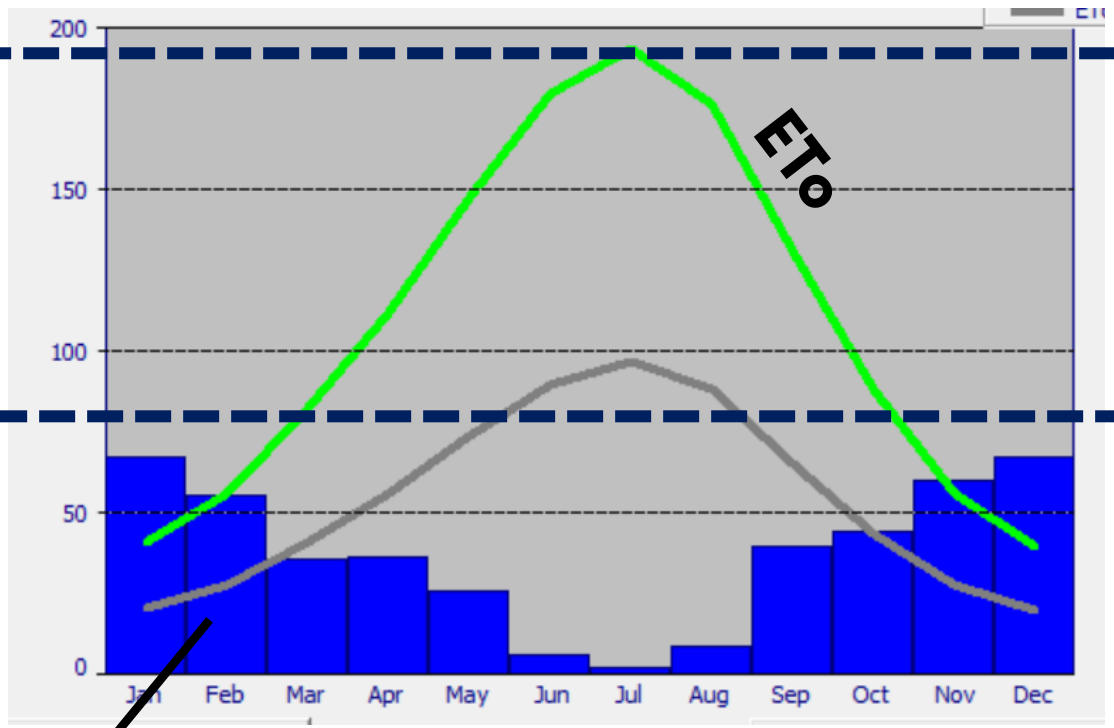


Ramallah (Palestine autonomous region)



Rain

Tunis (Tunisia)



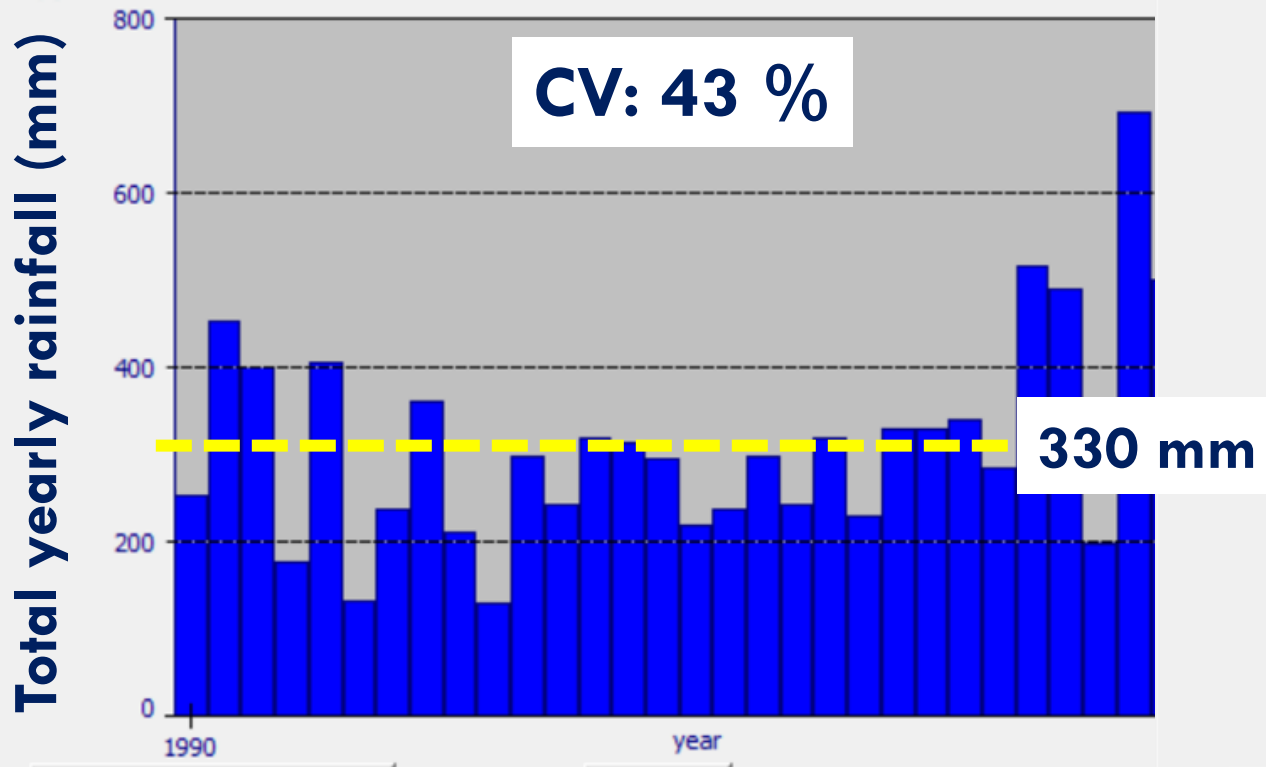
Rain

similar ETo

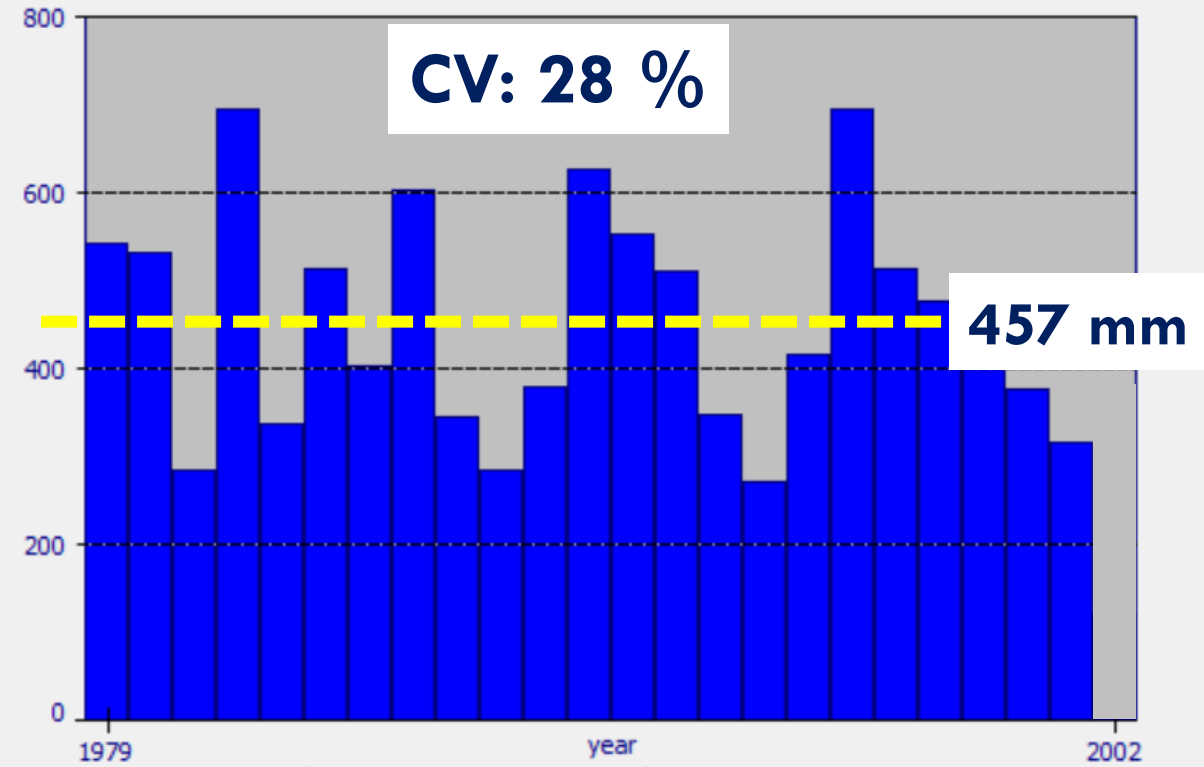
longer period of winter rains

Ramallah (Palestine autonomous region)

Tunis (Tunisia)



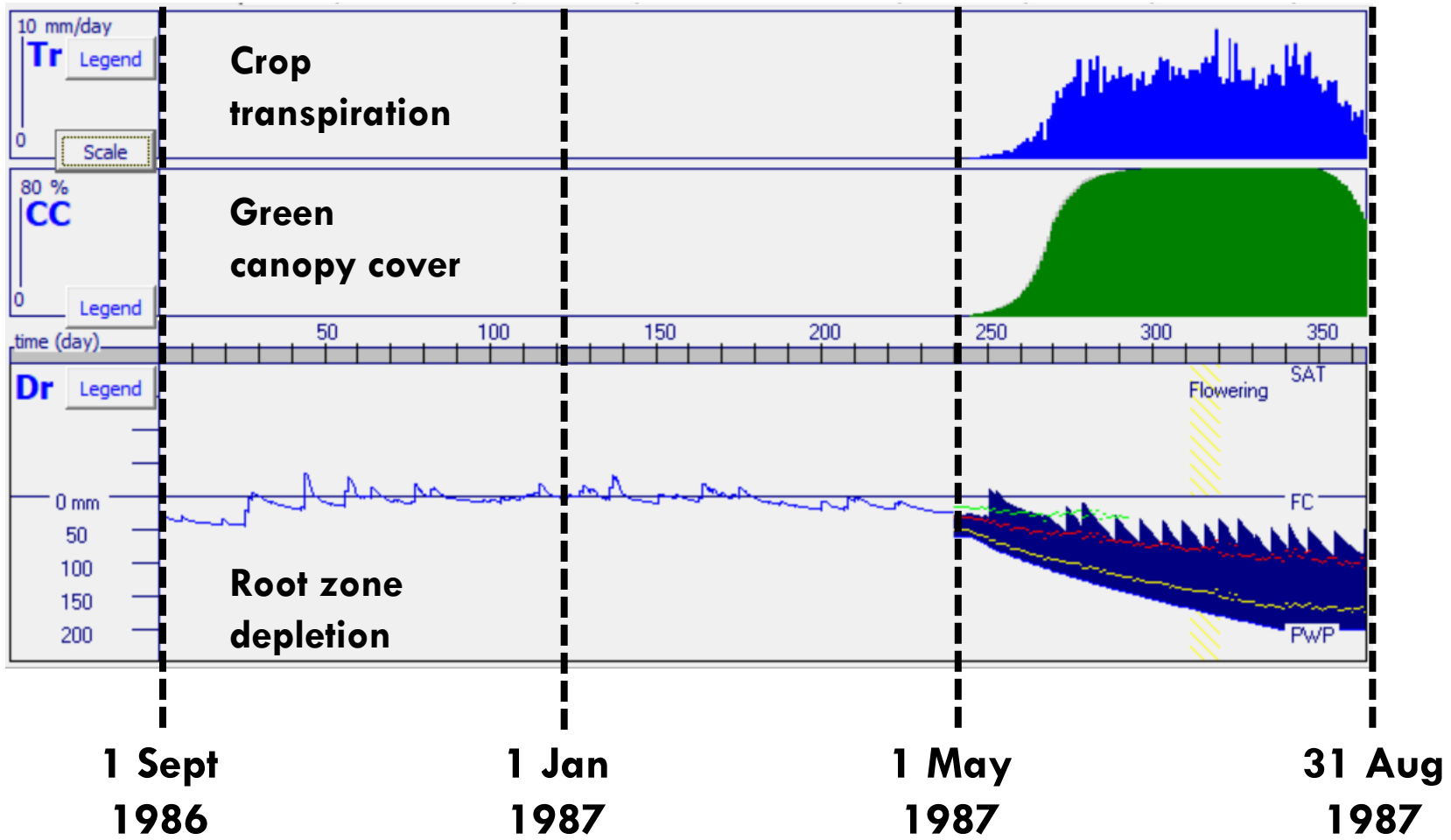
Climatic data: 31 years
Daily data: Rain & ETo



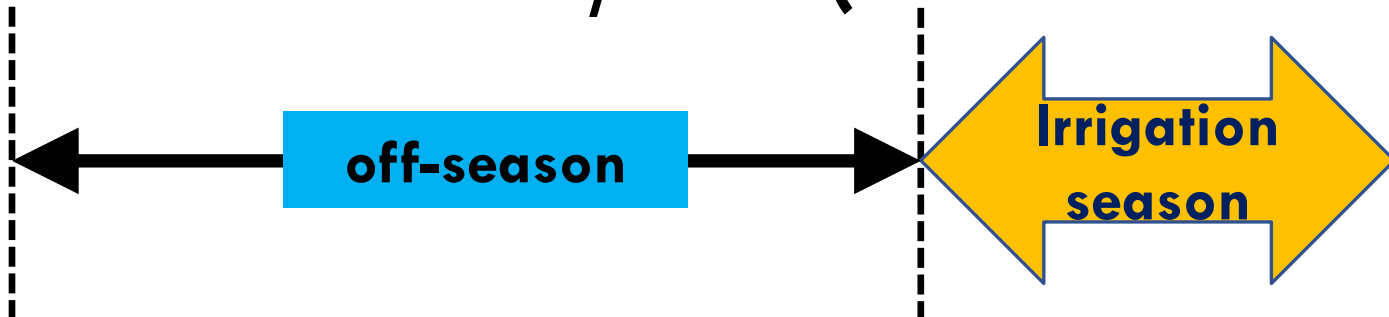
Climatic data: 21 years
Daily data: rain & ETo

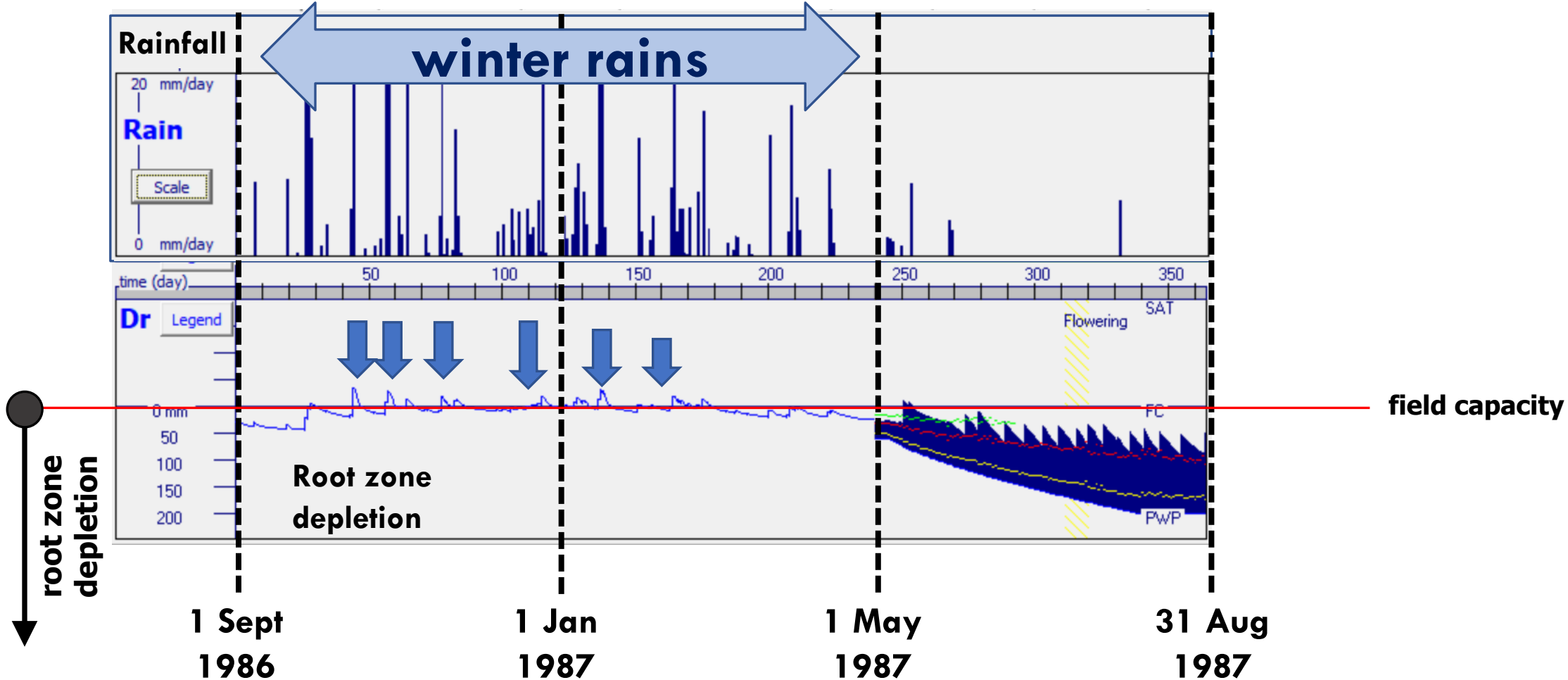
higher total rainfall

less yearly variation

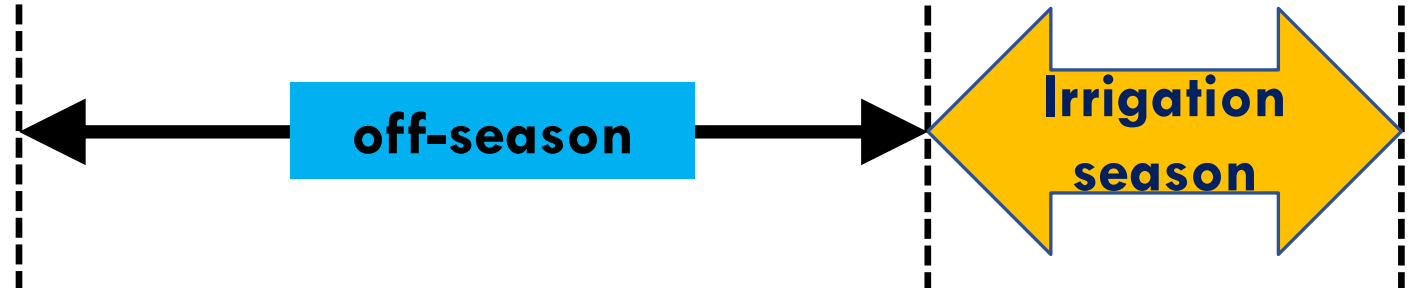


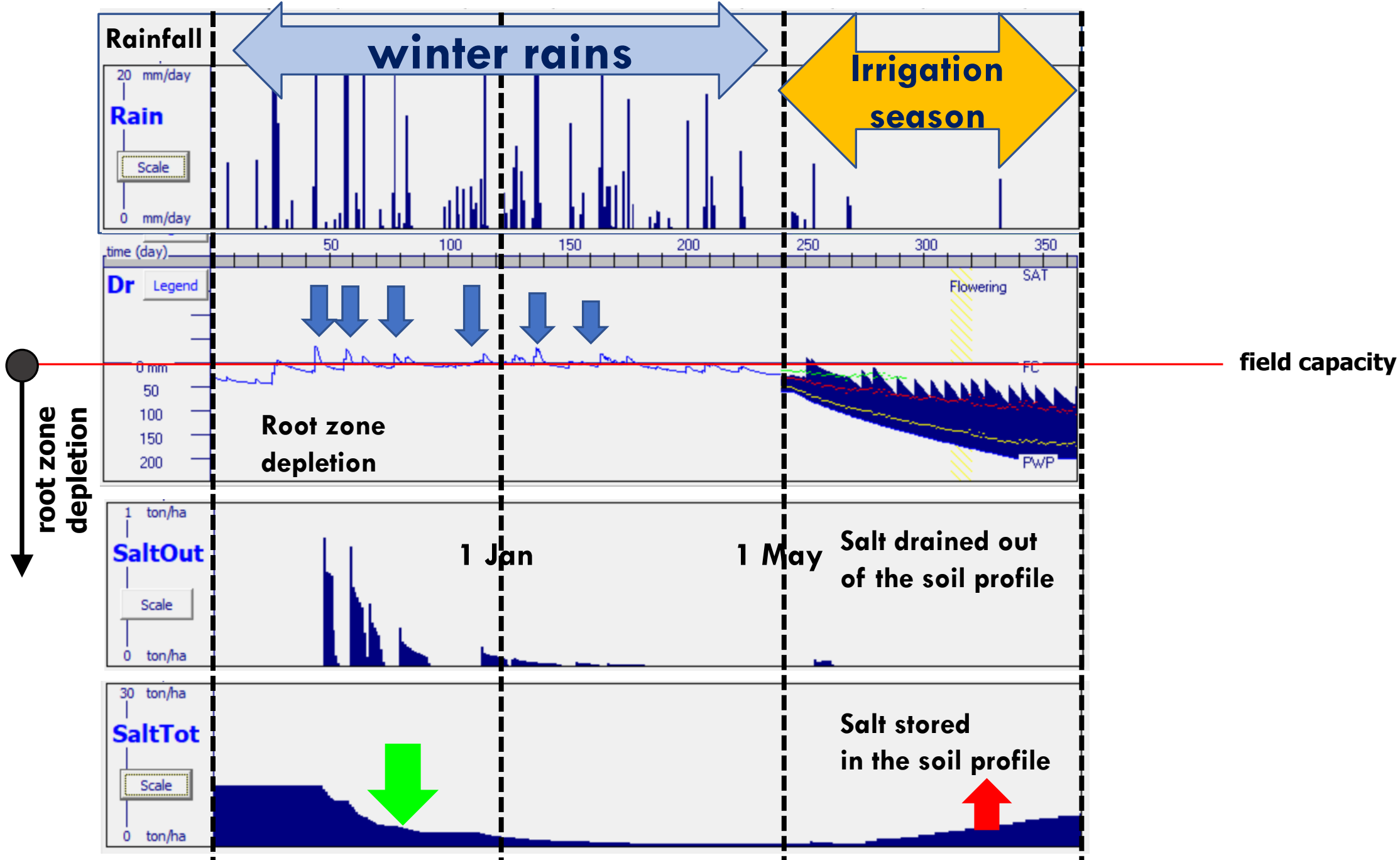
Simulation run 9/22 (1986 – 1987)

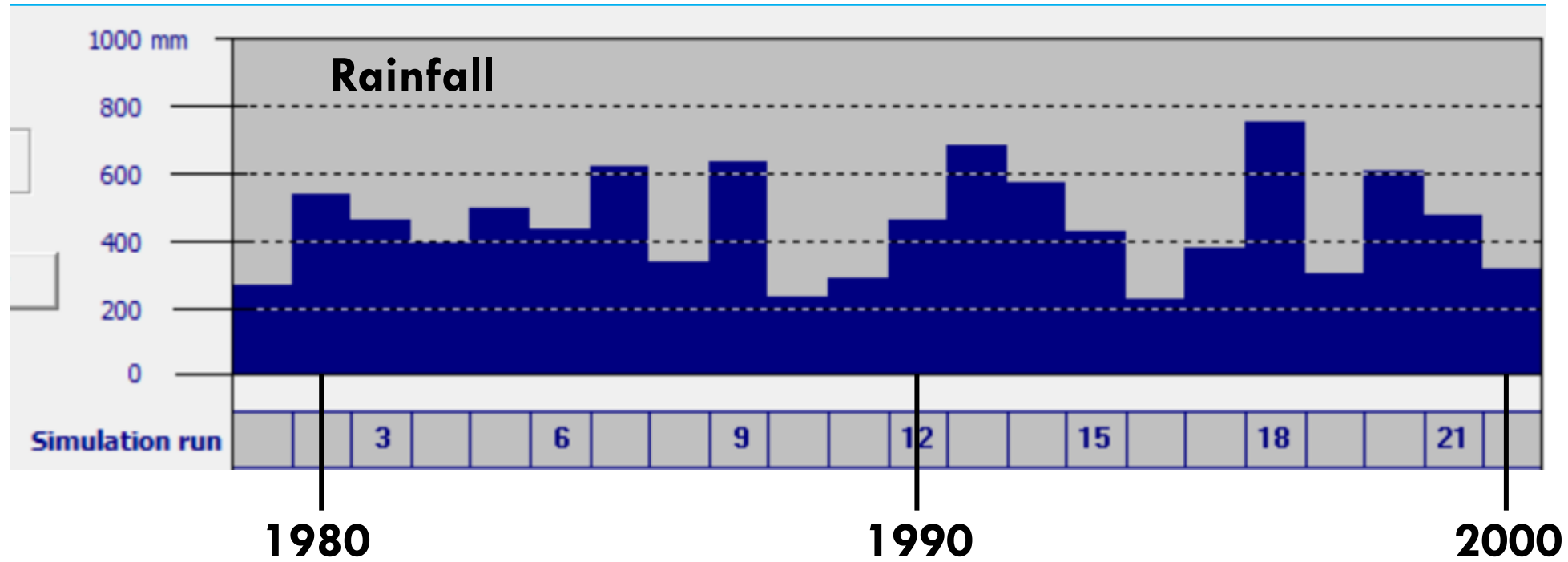




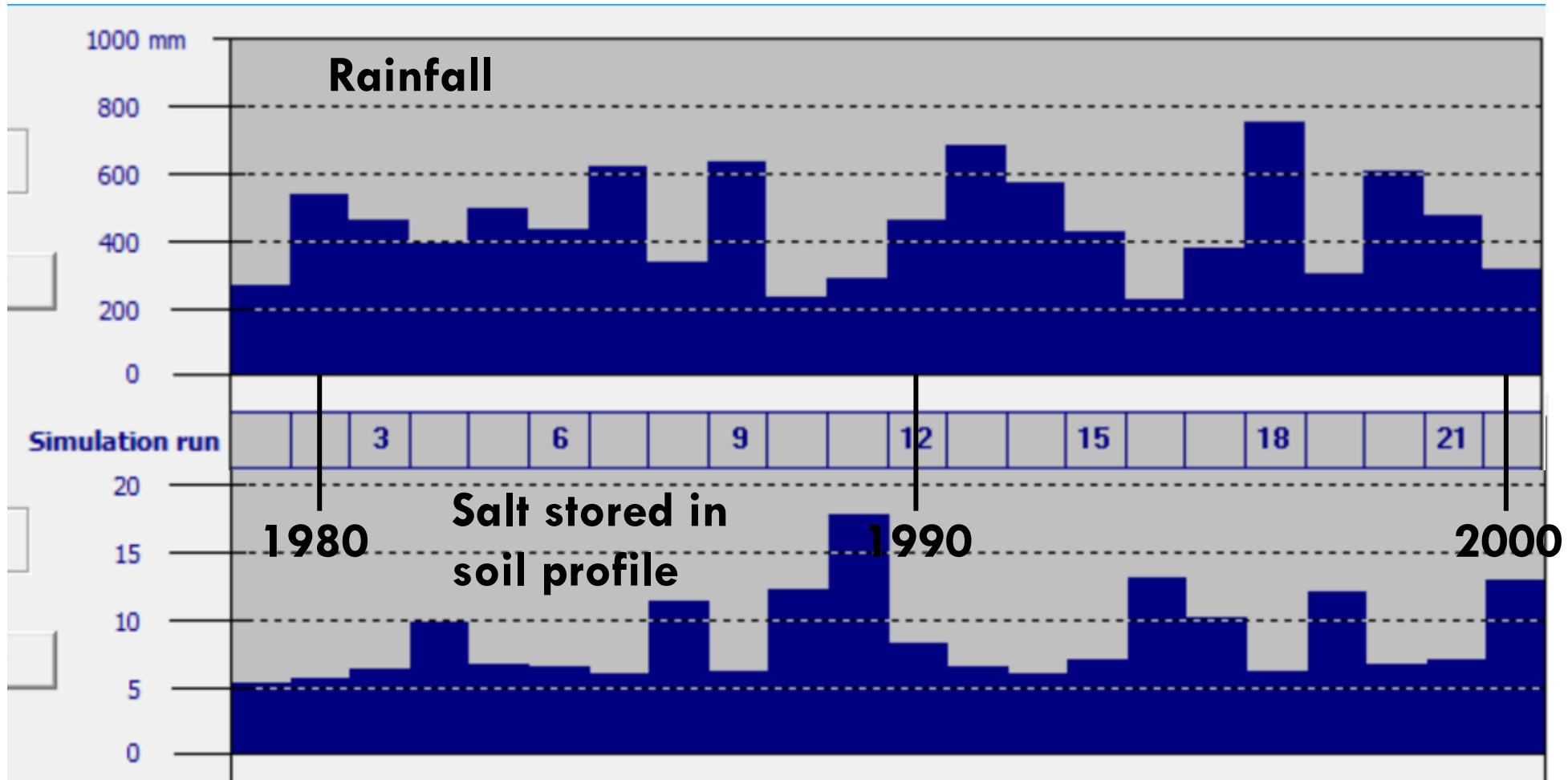
Simulation run 9/22 (1986 – 1987)

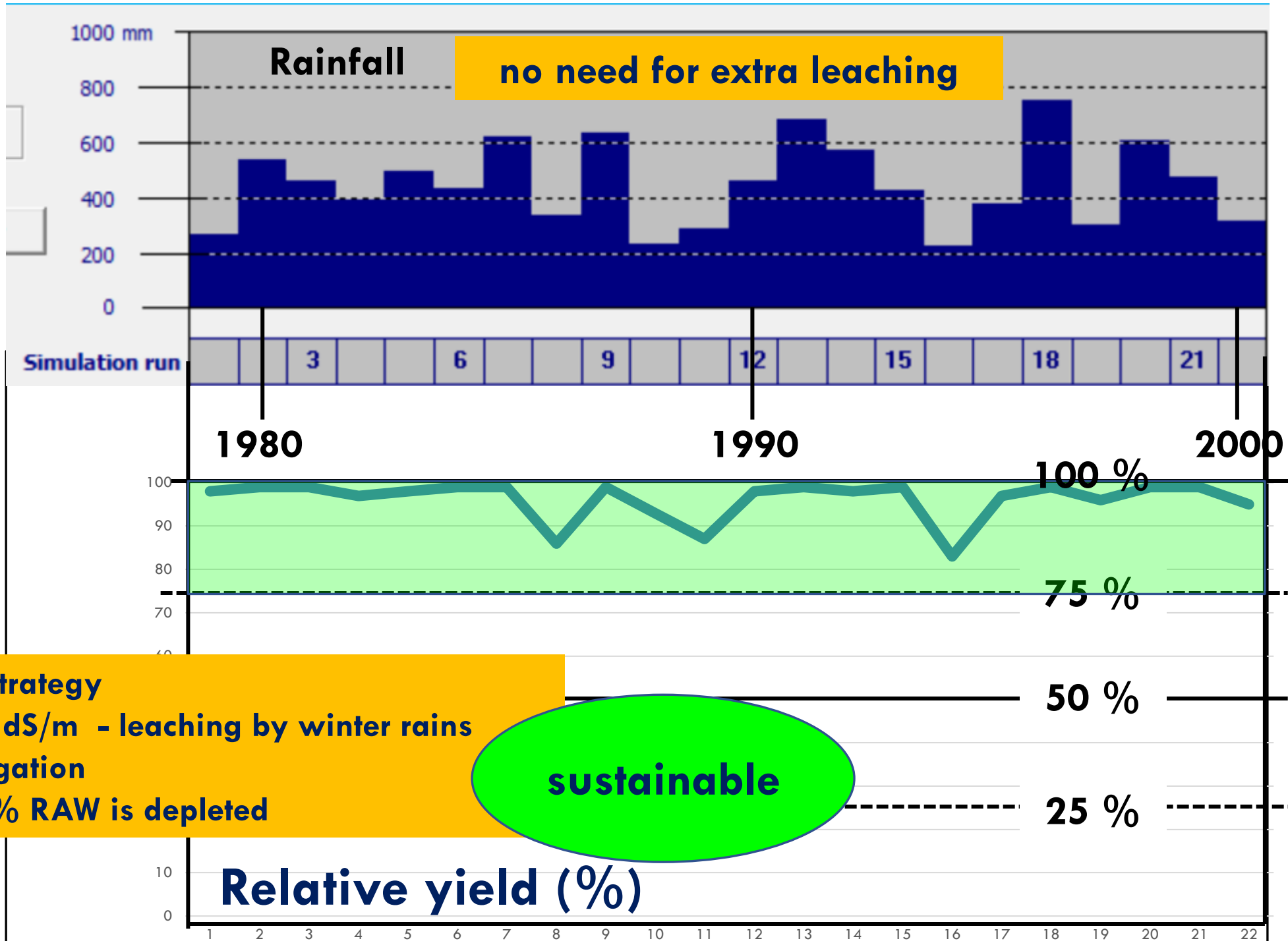






yearly output (21 years)

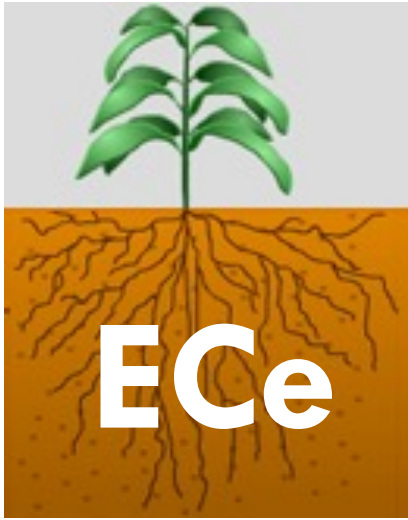




Irrigation strategy
EC_w = 1.5 dS/m - leaching by winter rains
40 mm irrigation
when 100% RAW is depleted

Relative yield (%)

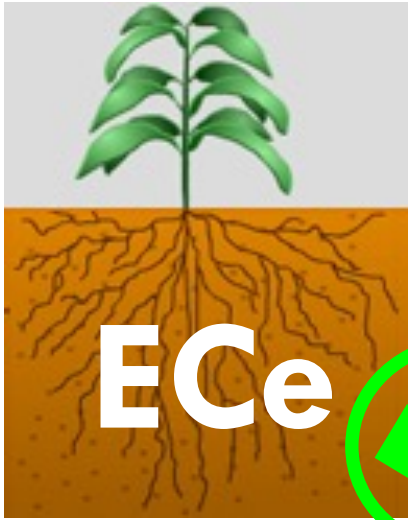
Conclusions



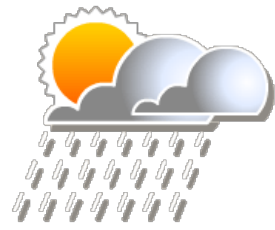
**effect of soil salinity
on crop yield**

**proper description
of the environment
is required**

Conclusions



effect of soil salinity
on crop yield



climate

- Rainfall amount & distribution
- ETo
- Air temperature



crop

- Planting date
- Length of growing cycle
- Tolerance to soil salinity



field management

- Soil fertility
- Rainfall run-off



Irrigation

- Irrigation method
- Irrigation schedule
- Water quality (ECw)



soil type

- Soil textural class (TAW, Ksat)
- Subsoil constraints (salts)



ground water table

- Depth
- Water quality



**Thank you
for your attention**

The boundaries and names shown and the designations used on these map(s) do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries. Dashed lines on maps represent approximate border lines for which there may not yet be full agreement.